How to comply with your environmental permit
Additional guidance for:

H1 - Technical Annex to Annex (j): Prior examination for discharges to land of waste sheep dip & pesticide washings

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Published by:
Environment Agency
Rio House
Waterside Drive,
Aztec West Almondsbury,
Bristol BS32 4UD
Tel: 0870 8506506
Email: enquiries@environment-agency.gov.uk
www.environment-agency.gov.uk

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About this Guidance

This document provides guidance on how to undertake a groundwater risk assessment (prior examination) of applications for the discharge to land of waste sheep dip or pesticide washings. This is a sector specific annex to our H1 Environment Risk Assessment Annex (j) Groundwater (Section 1.2). How this document fits in with our H1 guidance is shown in Figure 1.1.

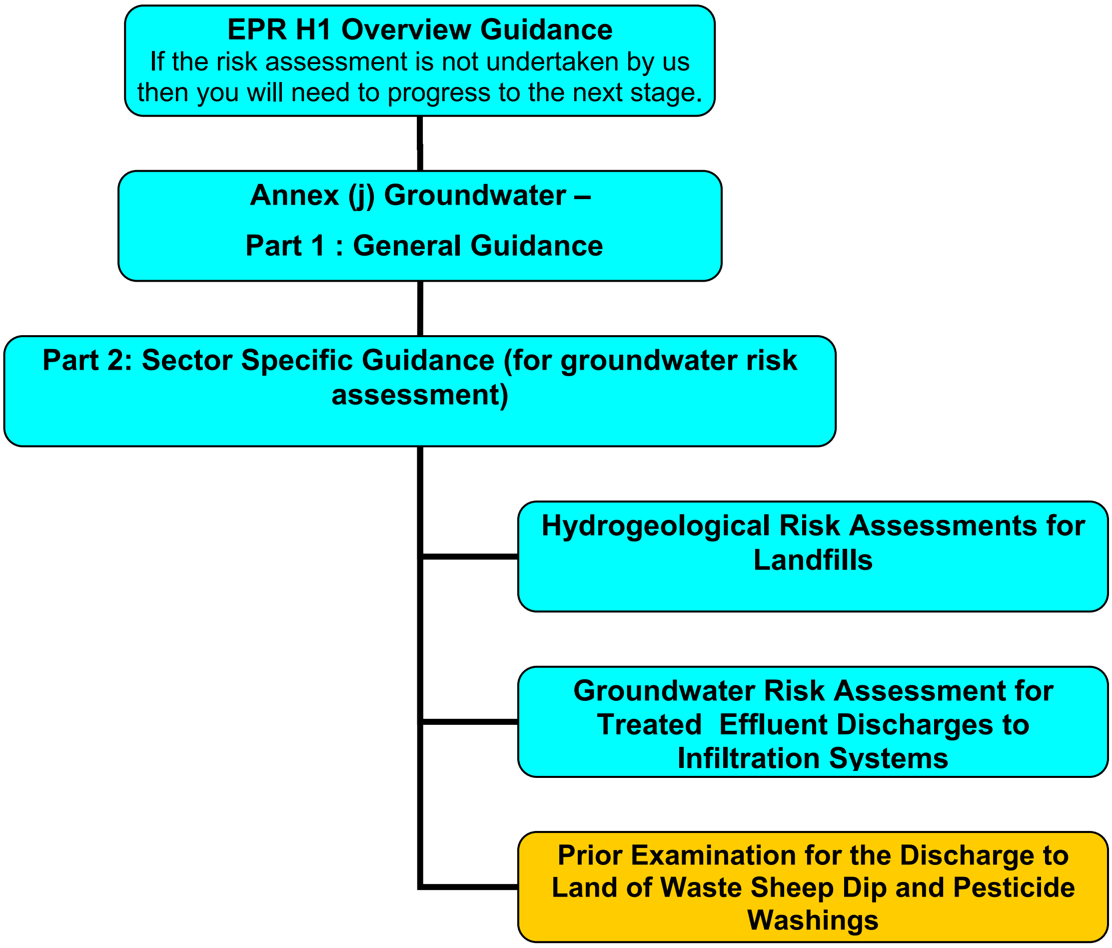

Figure 1.1 How the H1 Framework is Structured Specific to Groundwater

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Guidance is also provided on determining the degree of monitoring and *requisite surveillance* (as required by EPR 2010) that should be specified in granting a groundwater activity environmental permit (hereafter referred to as “permit”), and our role in ensuring that the conditions of such permits are followed.

Our risk assessment approach incorporates 3 Levels of assessment as follows:

- **Level 1**: An initial screening assessment;
- **Level 2**: A conservative quantitative assessment method;
- **Level 3**: A more detailed quantitative risk assessment.

Applications which pass our Level 1 assessment will typically be granted a permit. Those applications that fail can then be assessed using a higher level of assessment, but which will require additional information on your proposed discharge.

Under most circumstances we will undertake the Level 1 and 2 assessment for you. However, in rare circumstances, where the Level 1 or 2 risk assessment fails, we may request further information from you or ask you to undertake a Level 3 assessment.

You should follow this guidance if:

- We have asked you to undertake further assessment (i.e. your application has failed our initial assessment). In this case you will need to read the requirements set out in Section 3.4 and also refer to Annex (j) Groundwater for our general principles on what would be required for a more detailed groundwater risk assessment;
- You wish to understand how we have undertaken the assessment of your application;
- You wish to understand more about the requirements for monitoring of your discharge.

For most applications for the discharge to land of waste sheep dip or pesticide washings only a Level 1 or 2 assessment will be needed and we will undertake the assessment for you.

Previously our guidance was internally facing. We are now making this document externally facing so that it is clear as to the principles and procedures we use to assess your application.

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EPR H1 Environmental Risk Assessment Guidance

The 'EPR H1 Environmental Risk Assessment guidance' documents provide high level guidance on the broad principles of risk assessment, which underpin our decisions on the environmental permitting of different activities. It covers the need for risk assessments on concerns such as air quality, noise, stability, and potential impacts on surface water and groundwater. If appropriate, H1 then points you to more detailed guidance modules on how to undertake specific risk assessments. For groundwater, Part 1 (Annex (j) Groundwater) includes general guidance on groundwater risk assessment.

Discharge of Waste Sheep Dip and Pesticide Washings

Waste sheep dip and pesticide washings can be discharged (i.e. disposed of) by land spreading providing:

1. Such discharges are undertaken via a permit granted under EPR 2010; and
2. The activity in relation to the discharge is undertaken in accordance with recognised codes of good practice such as:

- Protecting our Water, Soil and Air: A Code of Good Agricultural Practice for farmers, growers and land managers;
- The Groundwater Protection Code – use and disposal of sheep dip compounds; and
- Using plant protection products (the "Pesticides Code")

This is to ensure that such activities do not present a risk to groundwater, surface water or the wider environment (such as nature conservation).

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Regulatory Requirements for Groundwater Risk Assessment

The regulatory requirements for a groundwater risk assessment are set out in Box A. Further information can be found in our Annex (j) Groundwater.

Box A Regulatory Requirement for Groundwater Risk Assessment

Applications for grant of environmental permit

EPR Schedule 22. Paragraph 7

(1) This paragraph applies to an application for the grant of an environmental permit relating to—

- (a) a discharge mentioned in paragraph 3(1)(a), (b) or (c); or
- (b) an activity that might lead to such a discharge.

(2) When the regulator receives an application, it must ensure that all necessary investigations have been carried out to ensure that it grants any permit in accordance with paragraph 6.

(3) If it grants the permit, it must include conditions requiring all necessary technical precautions to be observed to ensure the objectives of paragraph 6 are achieved.

(4) A permit may not be granted—

- (a) without examination of—
  - (i) the hydrogeological conditions of the area concerned,
  - (ii) the possible purifying powers of the soil and subsoil, and
  - (iii) the risk of pollution and alteration of the quality of the groundwater from the discharge, and
- (b) without establishing whether the input of pollutants to groundwater is a satisfactory solution from the point of view of the environment.

(5) A permit may only be granted if the regulator has checked that the groundwater (and, in particular, its quality) will undergo the requisite surveillance.

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A definition of hazardous substances and non-hazardous pollutants is given in Box B. The objective is prevent the input of hazardous substances to groundwater and/or pollution by non-hazardous pollutants (Box B). Most sheep dip compounds and pesticides are hazardous substances.

Box B Hazardous Substances and Non-Hazardous Pollutants

Definitions

Hazardous Substances are defined in the WFD as “substances or groups of substances that are toxic, persistent and liable to bio-accumulate, and other substances or groups of substances which give rise to an equivalent level of concern”

We are required to publish a list of hazardous substances and the Joint Agencies Groundwater Directive Advisory Group (JAGDAG) is the body that confirms these determinations.

Non-Hazardous Pollutants are any substances capable of causing pollution that have not been classified as hazardous substances.

Box C Preventing Inputs of Hazardous Substances and Avoiding Pollution from Non-hazardous Pollutants

Definitions

Inputs - any entry of a substance into groundwater from an activity or discharge, whether accidental or deliberate, point source or a diffuse source, that causes a release of a pollutant into groundwater.

Direct inputs can be identified by one of the following properties:

- They bypass the unsaturated zone;
- The pollution source is in the saturated zone (or discharges directly in the saturated zone);
- Seasonal fluctuations in the water table mean that the pollution source will be in direct contact with groundwater, for a significant period of time.

Indirect inputs are characterised by the discharge into groundwater after percolation through the soil or subsoil.

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An input of hazardous substances would be prevented if:

- There is no discernible concentration in the discharge, or
- There are no discernible concentrations of hazardous substances attributable to the discharge in groundwater immediately down-gradient of the discharge zone, subject to adequate monitoring (or in the case of new discharges a detailed predictive hydrogeological impact assessment), or
- There are (or are predicted to be) discernible concentrations in the groundwater down-gradient of the discharge zone attributable to the discharge but **all** of the following conditions apply:
    - (a) Concentrations will not result in any actual pollution or a significant risk of pollution in the future; and
    - (b) There will not be any progressive increase in the concentration of hazardous substances outside the immediate discharge zone, i.e. there will be no statistically and environmentally significant and sustained upward trend or significant increasing frequency in pollutant "spikes"; and
    - (c) There is evidence that all necessary and reasonable measures to avoid the entry of hazardous substances into groundwater have been taken (see below).

It is technically difficult to demonstrate that no hazardous substances will enter groundwater. There is always a lower reporting limit for analyses, and predictive probabilistic assessments produce progressively smaller finite numbers with decreasing risk rather than zeros.

The practical interpretation of no discernible discharge is that hazardous substances must not exceed the minimum reporting values (MRVs) at the point of compliance (see above). The presence of any hazardous substances should be environmentally trivial. A large amount of dilution at the water table cannot make a potentially significant hazardous substance loading 'not discernible'.

Necessary and reasonable measures

Assessment of necessary measures must be preceded by investigation to determine pathways and is a site-specific judgement.

A reasonable measure would be one where the necessary technical precautions to prevent inputs to groundwater are technically feasible, not disproportionately costly and are within the control of the operator. Such measures could include: source control, alteration of discharge mechanism, treatment of the discharge, interception or diversion of contaminated groundwater, and diversion to another disposal route.

In addition any measures taken should not result in a net environmental disbenefit.

If there is actual pollution, or a substantial risk of such pollution, remedial measures must be

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taken. Cost-benefit assessment is not a factor in deciding whether to take action in such cases but may be a consideration in determining which precautions will be imposed as conditions on a permit.

Pollution by non-hazardous pollutants

To avoid pollution by non-hazardous pollutants we must limit inputs of these pollutants into groundwater to ensure that:

- there is no deterioration in the status of the groundwater body;
- there is no significant and sustained upward trend in the concentrations of pollutants in groundwater;
- the concentrations of pollutants remain below a level such that harm to a receptor does not occur, or that local maximum allowable concentrations (such as quality standards to protect the groundwater resource) are not exceeded.

Target Audience

This guidance is primarily aimed at our staff in assessing the acceptability of submitted permit applications for spreading waste sheep dip and / or pesticide washings to land and for specifying monitoring requirements. However, this guidance is also publicly available for applicants, operators and consultants acting on behalf of landowners who wish to understand how our technical assessment procedures are applied to such a permit application.

Document Layout

This report has four main sections Following an introduction, the main processes affecting proposed discharges/disposals (e.g. processes that can influence the fate of contaminants (pollutants) discharged to land) is provided in Section 1. Guidance on the risk assessment approach in assessing applications is provided in Sections 2. Section 3 sets out a strategy for monitoring of such permitted discharges to the land.

The document also includes an Appendix A, that details the procedure that our staff will use for carrying out an initial assessment (Level 1) for an application for the land spreading of waste sheep dip and/or pesticide washings.

Technical Annex to Annex (j) – Prior examination for discharges to land of waste sheep dip & pesticide washings

Technical Annex to Annex (j) - Prior examination for discharges to land of waste sheep dip & pesticide washings

1. Main Processes Affecting Discharges (disposals)

1.1 Introduction

This section provides background information on the main processes affecting the discharge (disposal) of waste sheep dip and pesticide washings to ground via land spreading, and focuses on protecting groundwater from such hazardous substances and non-hazardous pollutants. The main processes considered are those that control contaminant migration in the soil zone and to a lesser extent in the unsaturated zone. Beneath the water table, only the process of dilution is considered and this is only for non-hazardous pollutants (i.e. is not applicable for sheep dip and most pesticides).

Figure 1.1 illustrates the general conceptual model of the environment being considered for land spreading and Figure 1.2 provides a schematic of the importance of different processes on the fate and transport of contaminants through the soil, unsaturated and saturated zone.

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Figure 1.1 General conceptual model

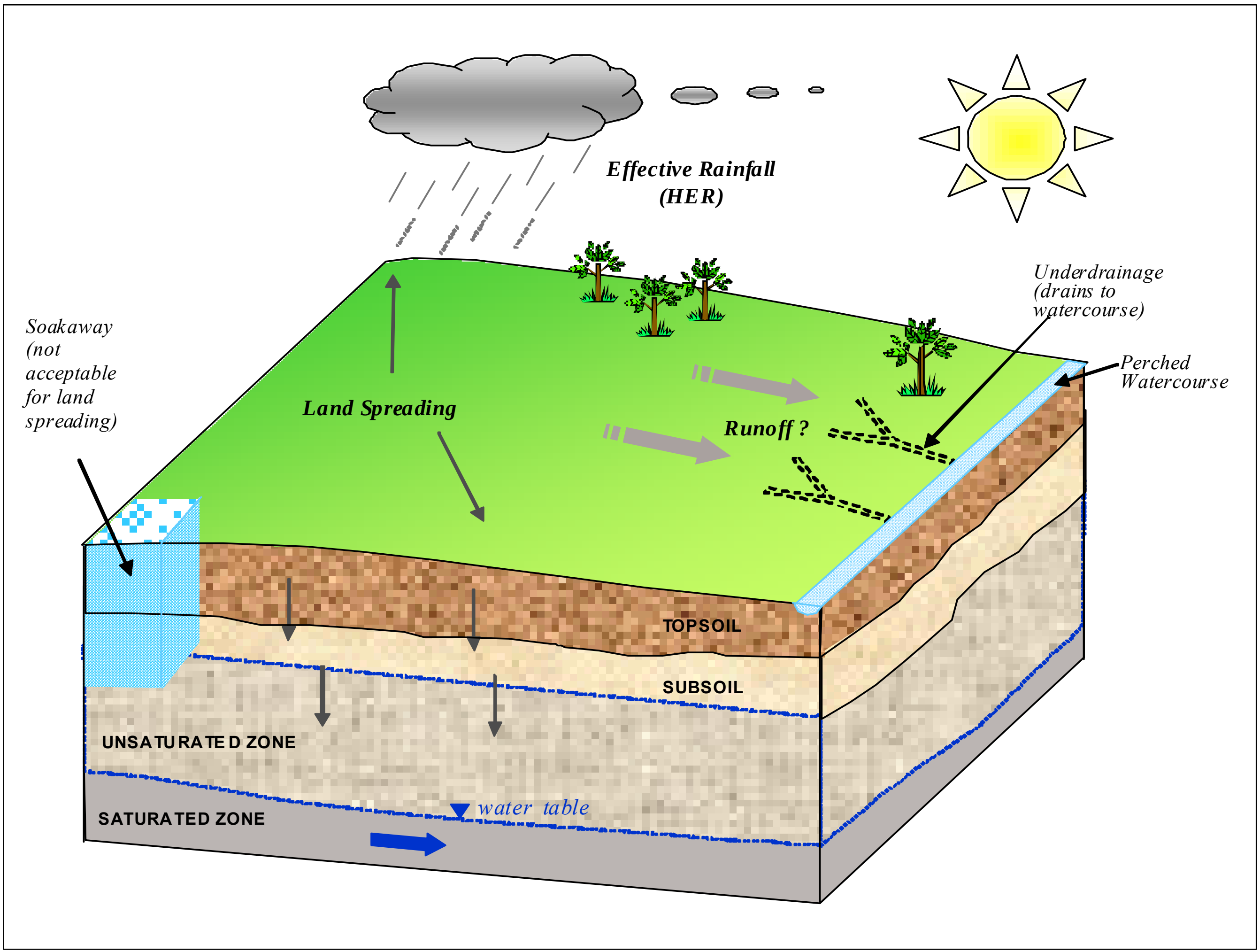
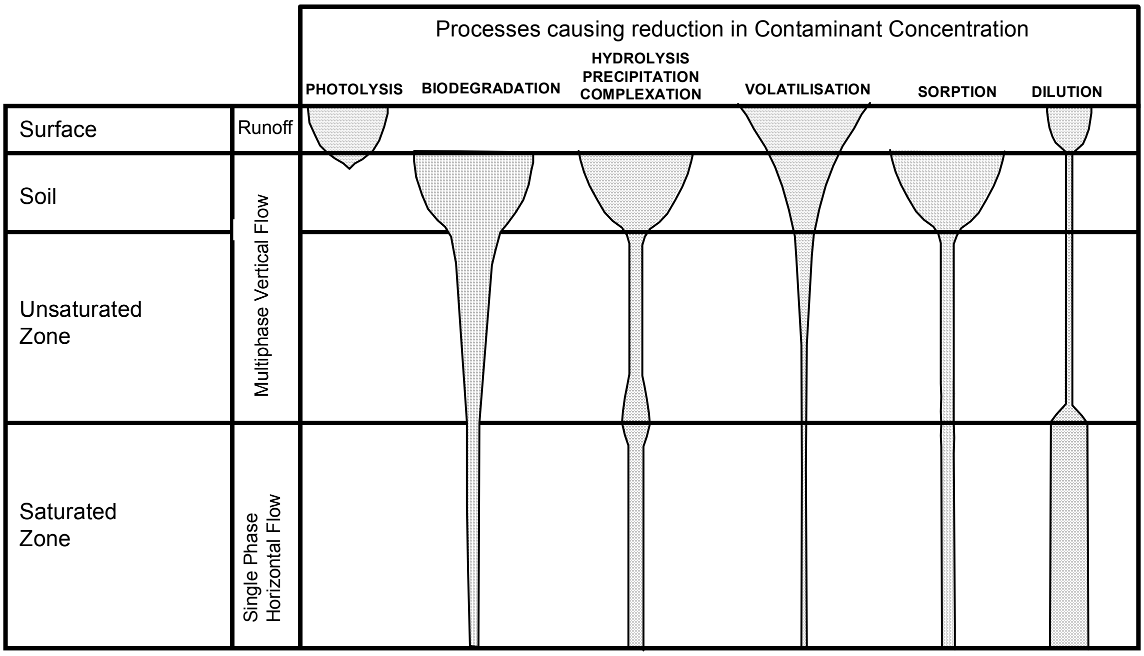


Figure 1.2 Summary of processes promoting contaminant attenuation in the soil, unsaturated and saturated zones (adapted from Foster 1988).



The thickness of the corresponding line indicates typically the relative importance of the process at the surface in the soil, and above, at and below the groundwater table

The processes, their controls and effects, are summarised in Table 1.1 and discussed briefly in the following sections in terms of how they can be quantified.

Our prior examination (risk assessment) procedure is described in Section 2 and it comprises 3 levels of assessment. We will undertake Levels 1 and 2 for you. Level 3 refers to the case where we may require you to undertake a more detailed risk assessment. The procedures for undertaking a Level 1 assessment are detailed in Appendix A. This section provides the relevant background information and describes the equations which have been used in our Level 2 screening tool.

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Table 1.1 – Main Processes and their Controls and Effects

Process	Section	Control	Effects
Hydraulic Loading or Rate of Spreading	2.4	Method of Application Rate of Application	Potential to overwhelm the infiltration capacity of soil and lead to runoff, or saturated or bypass vertical flow within the soil.
Runoff	2.5	Climate Slope Vegetation & Soil Type	Potential for contamination of adjacent land areas, pollution of surface waters or indirect contamination of recharge to groundwater.
Chemical Loading	2.6	Concentration and number of disposals	Source concentration with the potential to leach into runoff or to groundwater or to accumulate in the soil. Possible exceedence of sorption capacity, toxic effects on soil biology and effect on degradation rate.
		Contaminant Properties	Hazardous substances or non-hazardous pollutants, potential to volatilise, adsorb on soils, float, sink or leach in water, toxicity to soil microbial population, biodegradability.
Infiltration Rate	2.7	Hydraulic Loading Climate and vegetation Soil permeability, pore size and type Moisture Content	Variation in rate of downward movement of unretarded leached contaminant.
Sorption	2.9	Organic matter content Clay content and type, pH	Retardation of contaminants compared to infiltration rate. Possible inaccessibility for biodegradation.

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Volatilisation	2.10	Henry's Law Constant Soil air/water content Temperature	Contaminants are lost to air and so are unavailable to leach to surface water or groundwater.
Degradation (Abiotic and Biotic)	2.11	Concentration pH, temperature, air, water, clay and organic matter content, salinity, nutrients, oxygen. Acclimatisation of microbes.	Degradation rate is site specific (dependant on biochemical environment). Degradation leads to mass loss which is key for ensuring sustainability of operation and reducing concentrations. Breakdown products can be more mobile and toxic than the parent compound, though generally not. Biodegradation may be inhibited at high contaminant concentrations. There may be a time lag before microbial degradation becomes effective.
Mechanical Dispersion	2.12	Soil thickness and type of porosity	Faster (turbulent) flow in larger pores than smaller leads to spreading out of contaminants in the direction of water movement. This reduces average concentrations.
Diffusion	2.12	Concentration and type of porosity	Diffusion of contaminants between less mobile water in micropores and more mobile water in macropores.

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1.2 Use of Sheep Dip and Pesticides

Defra guidance on the handling and disposal of waste sheep dip and pesticide washings to ground can be found in a number of Codes of Practice, including:

1. Protecting our Water, Soil and Air: A Code of Good Agricultural Practice for farmers, growers and land managers;
2. The Groundwater Protection Code – use and disposal of sheep dip compounds; and
3. Using plant protection products (the “Pesticides Code”).

Such codes promote good practice in relation to the use and disposal of such materials. For example, waste sheep dip must not be disposed of in sensitive locations or when the land is waterlogged or frozen. Our risk assessment procedures (Section 2) have been designed to reflect the recommendations in terms of discharging hazardous substances and non-hazardous pollutants to ground via land spreading coupled with our understanding of hydrogeological processes and contaminant toxicity and the fate and transport behaviour of the pollutants.

For example, our risk assessments procedures ensure potable groundwater is protected by prohibiting waste sheep dip and pesticide washings discharges within a Groundwater Source Protection Zone 1 (SPZ1) - that is, close to springs, wells or boreholes used for domestic or food production purposes. We also ensure surface waters and conservation habitats are protected by restricting discharges close to rivers, streams European sites, Ramsar and Sites of Special Scientific Interest (SSSI), National and Local Nature Reserve, Protected Species Areas, etc.

Sheep dip compounds (such as diazinon) and pesticides are usually purchased as a concentrate and then made up to working strength according to manufacturer’s instructions. The formulation usually contains the active ingredient and ‘inert’ ingredient(s) (which may act as a solvent). The concentration of the active ingredient varies considerably from one product to another, and in some cases from one use to another, but is typically applied at a rate in the order of 1 kg/ha.

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Pesticides, along with sheep dip compounds (which are classed as veterinary medicines) cover a wide range of chemical compounds, and as such have widely varying environmental properties. Many pesticides are not soluble in water and so the resulting mixture can produce an emulsion of water and free phase product. Their ability, or not, to leach from soils to the water environment depends on complex interactions between the pesticide, the soil, and the weather in the days and months following application.

The conditions for safe use of pesticides are based on a combination of a product's Conditions of Approval for use (as stated on the Notice of Approval) and the general guidance in the Code of Practice for Using Plant Protection Products.

1.3 The Soil and Unsaturated Zone

Three distinct zones can be recognised at most sites. These are:

Topsoil - usually the highest organic content, roots and often a soil moisture deficit.

Subsoil - less organic content than the topsoil, but more than the unsaturated zone.

Unsaturated Zone - low organic content, possibly rocky substrata.

The properties of these zones (e.g. organic content, moisture content) will determine the rate of infiltration down to the water table and the importance of attenuation processes in reducing contaminant concentrations (see Figure 1.2).

Topsoils typically contain more organic carbon, have a higher microbial population and often have soil moisture deficits or higher overall moisture contents than subsoils or unsaturated strata. This means that both water and contaminant movement is slower in this layer and that degradation is faster. For many contaminants, therefore, the soil zone is the key zone for attenuation. Our Level 2 assessment method (Section 2.3) focuses on attenuation within the soil zone,

Organic carbon contents in topsoils (1 to >20%) are typically higher than in subsoils (typically less than 0.5%) and considerably higher than in unsaturated strata such as the Sherwood Sandstone (0.02 to 0.05%) and Chalk (0.01 to 0.05%) respectively (Pacey, 1989; Foster *et* *al*, 1991; Steventon-Barnes, 2000). The nature of the organic matter also tends to change with depth from amorphous organics to more mineralised. Both these factors mean that sorption of hydrophobic organics generally decreases significantly with depth.

Microbial activity decreases with depth generally due to decreased food source (organic carbon), but also due to less oxygen and nutrients.

Although the unsaturated zone will be characterised by a lower fraction of organic carbon content and lower rates of microbial activity, its thickness can be significantly greater than the soil zone and travel times though this zone can be significant allowing time for attenuation to occur.

Soils in England and Wales have been classified (Environment Agency 1999) into high, intermediate and low leaching potential. Within each leaching category there are a number of sub classes as follows:

- High (sub classes H1, H2 and H3);
- Intermediate (sub classes I1 and I2);
- Low (sub class L only).

In our Level 1 assessment (Section 3.2), we use this classification together with information on the thickness of the soil and unsaturated zone to assess the acceptability of your application.

Information on soil properties can be obtained from the National Soil Research Institute (NSRI)[1]. The NSRI is the custodian of the National Soil Inventory (NSI). The NSI data set contains soils data from 6127 points located on a 5 km grid across England and Wales. The data have been sub-divided into a number of datasets available as specific products:

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[1] Soil Survey data can now be obtained from the National Soil Resources Institute (NSRI), a centre within Cranfield University.

- **NSI Site -** contains information on soil series, erosion, land use, slope and lithology;
- **NSI Profile** – contains detailed description of soil profile including texture, colour, clay content, boundaries;
- **NSI Topsoil (1993 and 1995)** – contains measurements of over 20 elements/chemical parameters including pH, organic carbon content;
- **NSI Features** – contains information on depth characteristics and thickness of soil layers, and flood risk;
- **NSI Textures** – contains information on soil texture (sand/clay content).

This database also holds information on:

- Bulk density;
- Organic matter content;
- Water (moisture) retention;
- Total porosity;
- Clay/silt/sand proportions;
- pH.

The data are also displayed on a National Soils Map of England and Wales (NATMAP). This map displays the 300 mapped soil associations at a scale of 1:250,000. A variety of products based on this map are available from NSRI. The combination of NATMAP and NSI form NSRI's Land Information System – LandIS. LandIS and its associated products contain many additional calculations for properties such as bulk density, pore space, water retention as well as information from many unpublished research projects.

1.4 Rate of Disposal

Background

The rate of disposal of sheep dip or waste pesticide over an area will determine the hydraulic loading and, dependent on the soil and time of year, how quickly contaminants move through the soil zone.

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High rates of spreading can lead to:

- Rapid infiltration through the soil (by-pass flow) via large gravity-drained macropores (e.g. wormholes and cracks). This is likely to lead to limited sorption and limited time for degradation and thus a higher risk of groundwater contamination; and/or
- Exceedance of the field capacity of the soil leading to surface ponding, lateral saturated flow in the soil and in drains, and runoff on sloping ground. Lateral movement in drains and runoff can both lead to contamination of adjacent land areas and potential pollution of surface waters.

Lower hydraulic loading rates allow the downward movement of the water and its contents to be delayed by:

- Restoration of any soil moisture deficit;
- Diffusion of contaminants into smaller saturated pore spaces;
- Sorption of contaminants onto the soil (clays, organic matter etc).

This delay provides time for degradation to reduce the concentrations of contaminants applied.

Determining suitable rates of land spreading

Sheep dip and waste pesticides are usually disposed of by spreading over an area of land using either a sprayer or from a slurry/vacuum tanker. Rates of spreading are usually expressed in terms of m^3/ha/day. The Codes of Practice (Defra, 2006, 2009) provides recommendations on spreading rates.

Our initial (Level 1) prior examination risk assessment procedure for land spreading of sheep dip and other hazardous substances (see Section 2.2) considers what maximum rate is reasonable.

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For waste sheep dip, this equates to 5 m^3/ha if the dip is undiluted, rising to an upper limit of 30 m^3/ha/day[2] for used dip that has been appropriately diluted. Discharges at rates higher than this are not acceptable and current good practice recommends typical spreading rates of 20 m^3/ha/day.

Note: For enzyme treated sheep dip (Environment Agency 2010b), we require that the daily application rate should not exceed 20 m^3/ha/day if diluted in the ratio of 1 part working strength dip to 3 parts slurry or water, or again 5 m^3/ha/day if the working strength dip is undiluted.

The discharge of waste sheep dip must not be undertaken more frequently than once per year on any individual area of land, although areas may be used in rotation, to allow a maximum of 3 discharges per year within the disposal site as a whole.

For pesticide washings, our prior examination procedures (Section 2) allow for the fact that, when compared to sheep dip disposals, discharges are generally of much higher volumes, but more dilute. As such discharge rates greater than 30 m^3/ha/day are potentially acceptable, but these would need a more detailed site specific evaluation (Section 2).

Method of discharge

Our assessment assumes that the discharge is to ground via land spreading, so that the attenuating properties of the soil can be brought into play. Methods that spread the effluent evenly over an area are preferred as these ensure that each part of the discharge area has the same low loading rate. Such methods include use of spraying equipment (particularly for pesticides) or slurry vacuum tanker spreading equipment (e.g. for sheep dip).

Some spreading equipment (e.g. vacuum tankers) may have a fixed spreading rate which may exceed recommended rates for undiluted waste sheep dip. In this case it will be necessary to dilute the dip with slurry or water before spreading (see Appendix A: Spreading rate guidelines).

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[2] 30 m^3/ha/day equates to an infiltration rate of 3 mm/day or assuming spreading occurs over one hour, 3 mm/hour for that hour.

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Some methods, whilst discharging of the same volume over the same total area can lead to much higher loading rates locally. Methods such as tipping the liquid out of a container onto the land or "pulling the plug" on a sheep dip bath are contrary to good practice (Defra, 2006, 2009) are unacceptable as they are outside the terms of the environmental permit.

1.5 Runoff

Background

The main concern is washing off of contaminants (dissolved or particulate) retained on the land surface by subsequent rainfall and runoff into adjacent streams and swallow holes or onto adjacent land.

The potential for runoff depends on:

- Rainfall intensity and amount;
- Slope of the land;
- Vegetation (more runoff and higher particulate load from bare soil than grassed land); and
- Soil type and wetness.

The risk of runoff during the land spreading operation is low at rates of <3 mm/ha/day, except for slopes of 1 in 5 (11°) or steeper. Our Level 1 screening procedure will screen out proposed disposals where slopes exceed this and we will advise you to modify your application.

Determining likelihood of runoff

The likelihood of contamination of surface waters by runoff from land spreading areas, either during the application or by subsequent rainfall, is controlled by conditions on the permit.

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These are that no discharge shall take place on land:

- Within 10 m of the nearest watercourse, or 30m from a river designated as a European Site, SSSI or SAC;
- Within 25m of an identified swallow hole (*optional condition where such features may occur*);
- With a slope greater than 11° (~1 in 5);
- Has been under drained or mole drained within 12 months prior to any discharge operation, or is cracked down to the drain or any backfill; and
- Which is frozen hard or snow covered, liable to flooding, is severely compacted or waterlogged.

Data

Slope angles can be obtained directly from topographic maps as well as from the slope classes used by the National Soil Resources Institute (NSRI).

Data on the tendency for different soil types to be waterlogged and their standard percentage runoff factors are part of the Hydrology of Soil Types (HOST) Class system described by the Centre for Ecology and Hydrology (CEH).

1.6 Chemical Loading

Background

The chemical loading rate is the total amount of chemical spread on the land. It is defined by the concentration of the substance(s) or chemical(s) multiplied by the hydraulic loading rate per area per discharge and by the number of discharges (per year).

The loading rate, together with the degree to which attenuation processes reduce the concentrations of hazardous substances and non-hazardous pollutants, will determine the risk to groundwater.

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The following factors will also influence the risk from the discharge activity through:

- The amount of some substances may degrade only slowly at high soil concentrations or low chemical that could be adsorbed by the soil. (see Section 1.9 for more discussion on sorption);
- The build-up of non-degradable or very persistent chemicals in the soil over time;
- Degradation rates;
- temperatures.

Type of chemicals

The properties (e.g. leachability, persistence) of the chemical will affect its fate in terms of loss from the soil through volatilisation, degradation (photolysis, hydrolysis and biodegradation) or desorption and leaching to groundwater. Substances can be divided into three main groups, based on their mobility (i.e. persistence and leachability), as shown in Table 1.2.

Some types of substances (insecticides, herbicides, sheep dip etc) fall into each of the three groups and there is a transition between each group. Within each group there are hazardous substances and non-hazardous pollutants.

Table 1.2 – Groups of Substances Considered

Substances	**High Mobility**	**Moderate Mobility**	**Low Mobility**
Pesticides & sheep dip compounds	Aldicarb	Lindane	Most organochlorines: Diazinon Most organophosphates Chlorfenvinphos Dichlorvos Dimethoate Synthetic pyrethroids Permethrin Cypermethrin
Herbicides	Chlorotoluron Mecoprop Bentazone Triazines: Atrazine Simazine.	Isoproturon Diuron Carbendzim	MCPA
Metals	Selenium	Aluminium Arsenic Chromium Lead Nickel Zinc	Copper Mercury Cadmium
Biocides	---	Formaldehyde	---
Others	Nitrate Fluorides Chloride (high concentrations)	Ammonium Phosphates	---

Note:

It is important to note that some substances that are degradable in aerobic environments are persistent and highly mobile in the groundwater environment (which is often low in oxygen). Moreover assessments of the risk of migration of substances based on their normal use may not be appropriate to the conditions of disposal of wastes containing those substances.

Where mixtures containing several polluting substances are involved, our prior examination assessment is undertaken on the basis of using the most mobile significant component.

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Data

Wherever possible in your application, you should record the active ingredients or product name of the waste products to be discharged, together with the volume for disposal. It should be noted that a permit is not usually specific to a particular compound and may only specify, for example, 'sheep dip' or types of sheep dip e.g. organophosphates. The exact chemical nature of proprietary sheep dip may change over the period of the permit and this is one reason why we have a review period for permits (Section 4). Given the variation in the properties of different chemicals, this means that in our prior examination procedures we conservatively base our risk assessment on the most persistent, toxic and mobile chemical in the group of chemicals being used.

For pesticide washing and waste sheep dip discharges, the concentration of the application should be compared to the working strength recommended by the manufacturer. It is likely that much of the environmental data for a particular compound will relate to this strength. Applications of compounds in excess of the working strength are prohibited as it is against the product instructions.

Information on the chemical properties and fate mechanisms of different substances is available in a number of standard texts or databases available on the web. Examples include:

- Handbook of Environmental Data on Organic Chemicals (Verschueren, 2001);
- Handbook of Environmental Degradation Rates (Howard *et al*, 1991);
- OSU Extension Pesticide Properties Database (Vogue *et al*. 1994);
- Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals Volume 5 Pesticide Chemicals (Mackay *et al*, 1997);
- USEPA Soil Screening Guidance (1996);
- Environment Agency and SEPA internal database for substance classification purposes;
- Chemicals Regulation Directorate (www.pesticides.gov.uk);
- Pesticide Properties Database (http://sitem.herts.ac.uk/aeru/footprint/);
- Groundwater Chemicals Desk Reference (Montgomery J H and Welkom, L M, 2nd Edition 1996 or Montgomery J H, 4th Edition June 2007).

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1.7 Infiltration/Recharge Rate

Background

Once the waste effluent has been applied to land, the rate of movement of unretarded (no absorption) contaminants is controlled in part by the infiltration rate through the soil. Infiltration is assumed to be the water which percolates through the soil and unsaturated zone to the water table. For soils with no component of run-off (e.g. coarse soils) the infiltration rate will be equivalent to effective rainfall. In comparison clay soils will typically only allow 20% of the effective rainfall to infiltrate.

For the area of land spreading the amount of infiltration will be a combination of rainfall infiltration and the spreading activity as expressed by the following equation:

$$I = (0.1 \times AR \times N) + Inf$$

Where

I = Total infiltration rate (mm/year)

AR = Application rate (m^3/ha/day)

N = Number of applications per year

Inf = Rainfall infiltration (mm/year)

Data

Effective rainfall (HER) data are available from the Meteorological Office in their MOSES (40 km x 40 km grid square) data and should be obtained based on information on land use provided in the permit application. The basic land use options in MOSES are: deciduous trees, coniferous trees, grass, crop (winter barley), shrub, urban, bare soil and (inland) water.

The infiltration rate can be estimated using the base flow index (BFI) using the following equation.

$$\text{Infiltration Rate } (Inf) = HER \times BFI$$

Where

HER = Effective rainfall (mm/year) (although the calculation of travel times should be based on maximum monthly infiltration rates)

BFI = Baseflow Index

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The baseflow index can be obtained for different soil types using maps classified under the HOST system.

1.8 Travel Time through the Soil and Unsaturated Zone (Unretarded Travel)

Background

The travel time through the soil and unsaturated zone depends on the infiltration rate, but also depends on factors such as thickness, soil moisture deficit, moisture content, saturated vertical hydraulic conductivities. Interaction of the contaminant with the soil matrix (e.g. sorption) will slow (retard) the rate of movement.

A relatively simplistic approach to estimate unretarded travel times through the soil and unsaturated zone is to assume 'plug' or 'piston' flow, where water added at the surface of the layer displaces water held in the soil and leads to a release of water at the base of the layer.

This assumes that the soils are fully wetted, i.e. that there is no soil moisture deficit. The piston flow approach pushes the applied contaminants through the soil thickness as a discrete layer and ignores, from a concentration point of view, subsequent dilution (through hydrodynamic dispersion) from contaminant free infiltration.

The unretarded travel time (plug flow) can be calculated using the following equation:

$$T_u = \frac{z\theta_w}{I}$$

where:

T_u = the unretarded travel time through the soil (days)

z = the thickness of the soil (mm)

θ_w = the moisture content when there is no soil moisture deficit (fraction)

I = the average infiltration rate through the soil (mm/day) (based on monthly infiltration rates)

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To obtain a total unretarded travel time to the water table, this calculation will need to be undertaken for the topsoil, subsoil and unsaturated zones due to their different thicknesses and effective moisture contents.

An example calculation for the topsoil is given below.

Example calculation:

$$T_u = \frac{z\,\theta_w}{I}$$

assuming:

z = 300mm, θ_w = 10% and *I* = 550 mm/year or 1.5 mm/day

$$\text{then } T_u = \frac{300 \times 0.1}{1.5} \approx 20\ days$$

This example calculation indicates that unretarded contaminants have the potential to move rapidly through the soil and thin (<1 or 2 m) unsaturated zones. This leaves little time for degradation (if any) and so groundwater is likely to be impacted. This potential for rapid travel also means that it is more appropriate to use monthly rates of infiltration to determine travel times through the soil zone (see our Level 2 assessment method, Section 2.3).

This approach assumes conservatively that there is no soil moisture deficit and no lateral flow in the soil, but ignores bypass flow through macropores such as wormholes.

Soil moisture deficit can be important as, when present, water added to the soil will be taken up by capillary forces and under these conditions, plug flow will not occur until the SMD is restored. For applications made to the soil during periods when a SMD exists (e.g. the summer) then there will be a increase in the total travel time which can be estimated as follows:

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$$T_T = T_r + T_{lag}$$

Where

T_T = Total retarded travel time

T_r = Unretarded travel time through the soil

T_{lag} = Minimum number of days with SMD following application

Our Level 2 screening model (Section 2.3) allows this lag to be taken into account, however we will normally assume conservatively that no SMD exists.

For sites where the soil is underdrained, then this drainage may increase the risk to surface water and we will typically require further assessment (see Chart 2, Appendix A).

By-pass flow

By-pass flow occurs where water can move rapidly through the soil via macropores such as cracks and wormholes rather than via the intergranular porosity. Bypass flow is absent or uncommon in sandy (<~5-10% clay) coarse textured soils, as any larger pores created by worms and other burrowing animals collapse readily. The potential for bypass flow increases where soils contain increasing clay contents and organic contents. Increasing clay content causes soil particles to cluster together in 'peds' and makes the soil more mouldable (cavities from burrowing animals staying open) and more prone to desiccation cracking. Increasing organic content improves the structure and drainage of soils from a farming point of view, but increases ped (and macropore size). Increased organic content also leads to increased worm activity and to a greater potential to create large wormhole macropores. With a soil prone to bypass flow, bypass flow is most likely to occur during periods of intense rainfall.

Bypass flow is discussed by Larson and Jarvis (1999). It is believed that water movement in soils can be represented by piston flow in the micro-pores as long as the infiltration rate does not exceed the vertical hydraulic conductivity of the micro-pore system. Once exceeded, excess water (and any contaminants within it) moves rapidly under gravity through the macro-pores. LandSim's (Environment Agency 2007a) dual porosity option uses this approach to model flow in unsaturated chalk, for example.

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As long as the hydraulic loading rate during the application does not lead to bypass flow, and any contaminated water is held within the micro-pore system then it is assumed that infiltration moving during subsequent intense rainfall events has the potential to bypass much, if not all of the contaminants. This is, in part, due to slow diffusion rates (hours, days and for some soils months) between parts of the soil micropores to the larger pores (Jones *et al*. 2000) compared to the rapid travel times during storms. Bypass flow of relatively uncontaminated infiltration will also mean that the rate of flow in the micro-pores is overestimated. The main factor will be the time between an application and a rainfall event which could induce bypass flow. For rainfall events which occur within days of the application there is a high potential for movement of contaminants as bypass flow. With time, a greater proportion of the contaminant will be present within the micro-pore system or sorbed on to the soil matrix and is less likely to form part of bypass flow, as rates of desorption are typically slower than sorption rates.

Data

Determination of infiltration rates has been discussed in Section 1.7. Soil thicknesses (topsoil and subsoil) should be ideally measured on site. An indication of soil profiles can be gained from the soil profiles reported in Soil Survey Bulletins (e.g. Soil Survey, 1984). It should also be possible to provide an estimate of site-specific soil and subsoil thickness by interpreting the various databases held by the NSRI (National Soil Resources Institute) (Section 1.3). This database also holds information on soil moisture contents which should be used instead of the total porosity.

Information on the potential for by-pass flow can be obtained from the aquifer designation (previously the groundwater vulnerability) maps and from details supplied in the discharge application. The H1 soil leaching class includes soils which are susceptible to rapid flow, but some of the intermediate leaching soils are also prone to bypass flow. Soils with clay contents in excess of 20% or soils, on inspection in the field, which visibly have cracks or open structures, e.g. wormholes. Information on the clay content of soils can be obtained from the NSRI database.

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1.9 Sorption

Background

Many contaminants have a preference to adhere to soil particles rather than remain dissolved or suspended in water. This leads to the contaminants moving through the soil at a retarded velocity compared to the water. There are a number of processes included under this description:

- Filtration of particulates and micro-organisms;
- Precipitation of dissolved substances, particularly metals as metal carbonates;
- Cation exchange (electrostatic adsorption) of ammonium and some metals onto clays and some metal oxides;
- Adsorption of hydrophobic organics onto organic carbon (and to a much lesser extent clays);
- ‘Filtration’ of non aqueous phase liquids (NAPL’s) disposed to the soil as an emulsion;
- Adsorption of cationic hydrophilic organics (e.g. triazine herbicides) onto clays.

In assessing the likelihood of a substance moving through the soil and unsaturated zone, most contaminant transport models all assume that sorption can be represented by an instantaneous reversible linear equilibrium between the soil and water and by a soil/water distribution ratio, K_d. This assumption makes the mathematical simulation of the sorption process simple, but is not always conservative as it leads to an infinite capacity to adsorb. However, there have been a number of studies (e.g. Jones *et al*, 2000) in recent years that indicate that whilst sorption generally occurs rapidly, desorption is often kinetically controlled. Some desorption occurs quickly (in hours), but there are proportions of the contaminant that desorb slowly (rate constant of 10^{-3}/hr) or very slowly (rate constant of 10^{-5} to 10^{-4}/hr) due to diffusion and tight binding in micropores. So, overall, sorption is faster than desorption. The proportion of slow, plus very slow to rapid, desorption increases with increasing K_d. This slow desorption means that the assumption of instantaneous linear equilibrium sorption/desorption is conservative from the viewpoint of migration to groundwater and also that some contaminants will remain in the soil indefinitely if they are not degraded. More detailed discussion of sorption processes is given in Environment Agency (1999 and 2005).

In our Level 2 assessment (Section 2.3) we conservatively assume instantaneous linear equilibrium sorption/desorption.

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Sorption will determine the rate of movement of a contaminant through the soil and unsaturated zone. For inorganics the partition coefficient can be obtained from literature sources or from laboratory testing. For hydrophobic organics the partition coefficient (K_d) can be calculated as follows:

$$K_d = K_{oc} \, . \, f_{oc}$$

where

K_{oc} = organic carbon/water partition coefficient (l/kg)

f_{oc} = fraction of organic carbon in the soil.

The above relationship underestimates sorption at very low organic carbon contents (typically <0.1%) as sorption on clays becomes important. The minimum organic carbon content below which sorption on clays becomes important is contaminant specific. Generally, this is lower for higher values of K_{oc}.

The $K_d = K_{oc}.f_{oc}$ approach is used to conservatively represent hydrophilic sorption within our prior examination assessment approach (Section 2.3).

A complication is that many sheep dip formulations are emulsions and also contain other additives which, whilst not being active ingredients in themselves, may influence the physicochemical characteristics of the main active ingredient(s) as they can act as co-solvents. These processes are not considered in our Level 1 or 2 tools and would need to be considered as part of a more detailed (Level 3) risk assessment.

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Sorption and retarded contaminant transport

Sorption leads to contaminants being retarded compared to the water. This retardation factor (R_f) and the retarded travel time (T_r) can be determined using the following equations.

$$Retardation\ factor\ R_f = \left[1 + \left(\frac{K_d.\rho}{\theta_w}\right)\right]$$

where:

K_d = the soil/water distribution ratio or partition coefficient (l/kg)

θ_w = the water filled soil or unsaturated zone effective porosity (fraction)

ρ = the dry bulk density (g/cm^3).

$$\text{Retarded travel time } T_r = T_u\ .\ R_f$$

Where

T_u = the unretarded travel time (T_u) (Section 2.8)

This retarded travel time is the time until the arrival of the **peak** concentration, vertical dispersion being ignored.

Data requirements

Values for K_{oc} and K_d's can be obtained from the literature including those referenced in Section 1.6. However, literature values can be inappropriate and, where possible, soil specific tests are best carried out. This is because factors such as soil clay content and pH are important. Methods of determining K_d's are discussed in Environment Agency (2000a and 2005).

An important point when selecting values of K_d from the literature is to ensure that the values have been determined from comparable conditions (especially for hydrophilic organics and metals) and through consideration of similar concentration levels of similar formulations in the soils. This helps to reduce the importance of non-linear sorption, emulsions and co-solvency affects.

Organic contents are dependent on the climate, soil type and land use. An indication of likely organic content can be obtained from comparison of soil types on maps with soils data published in the Regional Soil Memoirs (e.g. Soil Survey, 1984) or from the NSRI database (Section 1.3). Alternatively laboratory analysis of the organic content can be undertaken on soil samples.

1.10 Volatilisation

Background

Volatilisation is the process of partitioning contaminants from the soil-water system into the vapour phase. Henry's Law constant describes this vapour/water partitioning for dissolved contaminants.

Many contaminants are not volatile, but for those that are, excluding the process of volatilisation from an assessment will conservatively over-predict the amount remaining in the soil or leached to groundwater.

In the risk assessment methodology described in Section 2.3, volatilisation is assumed to be accounted for in the soil degradation rate and so is not considered separately. Should volatilisation, photolysis, chemical degradation and biodegradation need to be considered separately, then this section provides some background on volatilisation and its assessment.

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The partition of a contaminant between soil, water and air can be described by the following equation:

$$C_t = C_w\left[K_d + \frac{(\theta_w + \theta_a.H)}{\rho}\right]$$

where:

C_t = the total soil concentration (mg/kg)
C_w = the concentration in the water (mg/l)
K_d = the soil/water distribution ratio (l/kg)
θ_w = the water filled soil porosity (fr)
θ_a = the air filled soil porosity (fr)
H = Henry's Law constant (unitless)*
□ = the dry bulk density (g/cm^3).

*Note: Henry's Law constant can also be expressed in units of Pa.m^3/mol or atm.m^3/mol. Conversion factors are given below:

1atm = 101300 Pa

Unitless Henry's Law constant = H(atm.m^3/mol)/[8.314 × T(°K)]

Solving this equation for soils in which the total voids are less than 90% water saturated, indicates that for Henry's Law constant values of up to 1[3], volatilisation will be unimportant (<20%) as long as K_d is greater than about 1. For values of H above 1, volatilisation will be unimportant (<20%) as long as K_d (l/kg) is not less than H (unitless).

Data

Henry's Law constants are provided in a number of environmental data 'handbooks', see Section 1.6.

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[3] For a volatile substance such as benzene the Henry's Law constant = 0.249

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1.11 Degradation

Background

Degradation is defined here as any mass-reducing process that leads to a reduction in concentration of a contaminant in the soil or water other than the processes of leaching and volatilisation.

Degradation processes are summarised in Box 1.1 and further details are given in (Environment Agency, 1999 and 2000b).

Box 1.1 Degradation processes

Photolysis (degradation of a contaminant by sunlight) is an important abiotic degradation mechanism for some contaminants such as pesticides and chlorinated solvents. It is only likely to occur on the soil surface or in surface waters through exposure to sunlight. Once the contaminant has infiltrated to the soil, this mechanism is unimportant as a mechanism for reducing risks to groundwater.

Chemical degradation (e.g. hydrolysis) is an abiotic degradation mechanism that occurs through the reaction of a contaminant with reactants in the environment, particularly oxygen (oxidation) and water (hydrolysis). Hydrolysis results in the replacement of one functional group (e.g. chloride) with a hydroxyl group and can lead to toxicity changes. Not all contaminants are susceptible to hydrolysis, but for pesticides, hydrolysis is a primary route for degradation.

Biodegradation (microbial degradation) is the breakdown of substances by microbially (biotic) catalysed reactions. The breakdown products can be as harmful as the original contaminant, although these 'metabolites' may also biodegrade. Organic compounds may be biodegraded by many different mechanisms and microorganisms (bacteria, fungi and actinomycetes). The three major mechanisms are:

- Catabolism or direct oxidation where the molecule is utilised as a nutrient or energy source;
- Co-metabolism where utilisation is coincidental to normal metabolic functions;
- By enzymatic action where microorganisms have secreted enzymes to the soil, such as phosphatases and amidases, which may persist long after the parent cells are dead.

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Biodegradation is likely to be the main mechanism that results in a decrease in the concentrations of pesticides in the sub surface environment. Many compounds undergo a series of biochemical transformations that eventually result in the complete removal of the compound. Most of these processes involve an increased preference for water over soil. Microbial degradation rates increase with a number of factors including increasing temperature, oxygen content (aerobic/anaerobic), availability of nutrients and degradable organic matter and size of microbial culture. This tends to make degradation rates higher in coarse soils than in clay-rich, high moisture content soils and peaty soils. As microbial populations and degradable organic contents are much higher in topsoils than in underlying mineral soils and unsaturated zones, degradation rates decrease rapidly with depth as illustrated in Figure 1.2.

For most compounds, aerobic degradation is several times more rapid than anaerobic degradation (Howard *et al*, 1991). Anaerobic degradation is important for some compounds such as chlorinated solvents, PCBs and DDT due to the process of reductive dechlorination. Between aerobic and anaerobic processes, the presence of dissolved nitrate, dissolved sulphate and iron and manganese oxy-hydroxides in the soils can support degradation at intermediate rates.

Each of the degradation processes is dependent to some extent on temperature. Compounds are more volatile at warmer temperatures and both chemical and biochemical reaction rates increase with temperature. This means that there will be some seasonal variations in degradation rates in soils. This seasonality will be highest in the near surface layers, but will be lower in the subsoil where temperatures will more closely reflect the annual average air temperature.

Application of a new contaminant to a soil means that there is often a lag time before the soil microbes are acclimatised and degradation rates are optimised. Lag times have been reported (in Hern and Melancon, 1986) to range from a few hours to a few months depending on the contaminant and its concentration. The lag period may be similar to the degradation half-life.

Repeat applications of the same pesticides and herbicides to the same soil under the same crop leads to an adjustment of the microbial population of the soil. This can greatly affect the persistence and therefore agronomic efficacy of some molecules (Vighi and Funari, 1995).

Crop rotation reduces this effect, preserves the efficacy of the molecules for the crop, but potentially leads to an increased risk to groundwater.

Degradation (abiotic or biotic) is often represented as first order decay reaction as follows:

$$C_t = C_0 .0.5^{\left(\frac{t}{T_{½}}\right)}$$

where:

C_t = the concentration in the source at time, t (mg/l)

C_o = the concentration in the source on application (mg/l)

t = time since the application occurred (days)

$T_{½}$ = the soil degradation half-life (days) ($T_{½} = ln2/□ = \sim 0.693/□$)

□ = the decay or rate constant (day^{-1}).

The above equation makes no allowance for acclimatisation of microbes which is a site-specific factor. It should not be significant for existing sites where discharges are regular, but may be significant for the first few discharges on a new site or at sites where disposals are very infrequent.

Data

There are a range of published data sources for degradation rates which are typically reported half-lives ($T_{½}$) or rate constants (□). Data sources are given in Section 2.6 and is also available on the Chemicals Safety Directorate website www.**pesticides**.gov.uk.

Literature sources of information include degradation rates for soils, groundwater and surface water and under aerobic and anaerobic conditions. For the soils, rates pertaining to aerobic conditions in soils should be used unless the soils are waterlogged, when anaerobic rates should be used. For subsoils and unsaturated zones, rates relating to aerobic conditions for groundwater are likely to be more appropriate than those for soil due to the different prevailing microbial conditions.

It is important to note that many literature values will be based on laboratory measurements and field studies in the United States and that these may therefore be relevant to temperatures closer to 20°C than typical annual average soil temperatures in the UK of about 10°C. Based on reaction rates typically doubling with a 10°C increase in temperature, degradation half-lives should be doubled unless the temperatures quoted in the literature are appropriate. Degradation rates can also be influenced by pH and by the concentration of the contaminant. Some contaminants are toxic to microbes and so tend only to be degraded when present at low concentrations. Degradation rate data for pesticides will be related to the working strength for a specified use. Consequently, applications of compounds in excess of the relevant working strength should be avoided as there may be variation in toxicity to soil micro-organisms with concentration and will be in contravention of the product use instructions.

Many data sources based on field and lab studies provide degradation in soil half-lives. It should be noted that these data can incorporate all the processes of volatilisation, sorption, hydrolysis and microbial degradation. When these soil half-lives are used, it is important not to double count other processes such as volatilisation.

1.12 Hydrodynamic Dispersion

Hydrodynamic dispersion comprises the processes of mechanical dispersion and molecular diffusion.

Mechanical dispersion occurs as a result of water flowing through a porous medium at different velocities. This is because flowpaths differ depending on the porosity and hydraulic conductivity of the route taken.

Mechanical dispersion increases with increasing velocity and so tends to be less significant in the unsaturated zone than the saturated zone (Environment Agency, 1999). However, it can be important in soils with a high macroporosity as a result of more rapid transport in the macropores than in the micropores of the soil.

Molecular diffusion is the movement of contaminants from high concentration areas to low concentration areas. This leads to contaminants moving from larger to smaller pores that are otherwise not accessed by moving water. Diffusion is generally very slow compared to flow rates but can be important in low permeability soils or dual porosity strata and soils with significant macroporosity. This process does not remove mass from the system, but slows down the contaminant movement and thus allows more time for degradation processes.

The two parameters that describe diffusion and mechanical dispersion are combined to provide the hydrodynamic dispersion coefficient, D:

$$D = \tau D_w + \alpha.v = D^* + D_d$$

where:

D = hydrodynamic dispersion (m^2/d)
D^* = mechanical dispersion (m^2/d)
D_d = molecular diffusion coefficient through medium (m^2/s)
$\alpha.$ = dispersivity (m)
v = groundwater velocity (m/d)
τ = tortuosity of medium
D_w = molecular diffusion coefficient in water (m^2/d)

For permeable soils then molecular diffusion is likely to be negligible compared to mechanical dispersion and the above equation can be simplified as:

$$D = \alpha.v$$

1.13 Dilution

Background

Dilution is the reduction in concentration of a contaminant leaching from the base of the unsaturated zone by mixing with groundwater beneath the water table. Mixing in the aquifer may not be with all the groundwater flowing beneath the site due to stratification. However, sampling of groundwater from a monitoring well or abstraction well will lead to mixing of the water in the screened section of the borehole.

Dilution by groundwater can be considered for non-hazardous pollutants. Dilution can, in theory, be considered to a limited extent for hazardous substances in the context of the

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meaning of "prevent" as noted in Box C. However, it is a prerequisite that long term monitoring of groundwater immediately down-gradient of the discharge is in place. In most instances of waste sheep dip and pesticide disposal (which are mostly hazardous substances) this will not be the case. Therefore dilution is not normally appropriate to the assessment of such discharges.

Dilution is not considered in our Level 1 and 2 assessment methods, but can be considered as part of a Level 3 assessment (Section 2.5), if appropriate.

Estimating groundwater flow beneath a site

Flow beneath the site can be estimated using a Darcy Flow approach or groundwater catchment method.

The ***Darcy flow approach*** uses the equation:

$$Q_{gw} = Kiwd_a$$

where

Q_{gw} = the estimated flow beneath the site (m^3/day)

K = the hydraulic conductivity of the strata (m/day)

i = the hydraulic gradient (m/m)

w = the width of the site perpendicular to the flow direction (m)

d_a = the saturated depth of aquifer beneath the site (m)

For some sites there will be good control on the site width and saturated aquifer thickness, but hydraulic conductivities will rarely be known to better than an order of magnitude even with extensive field data.

The ***groundwater catchment approach*** uses the equation:

$$Q_{gw} = A_{gw}.I$$

where

A_{gw} = the groundwater catchment area estimated from groundwater contour maps or for unconfined aquifers approximated to the surface water catchment (m^2)

I = the estimated recharge rate over the groundwater catchment area (m/d).

Ideally the two methods should be compared for consistency and checked for plausibility.

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Mixing zones

The groundwater mixing zone beneath a disposal area will typically less than the aquifer thickness and can be estimated based on a hydrogeological evaluation of the site using the equation (from USEPA, 1994):

$$b_{mz} = \left(0.0112L^2\right)^{0.5} + \left(d_a\left(1-\exp\left[\frac{-L.I}{K.i.d_a}\right]\right)\right)$$

where:

b_{mz} = the vertical mixing depth (m) at distance L. Note b_{mz} cannot exceed the saturated aquifer thickness d_a.

L = the distance (m) in the direction of groundwater flow that mixing is considered (arbitrarily 10 to 50 m);

d_a = the saturated thickness of (isotropic) aquifer (m);

I = the infiltration rate through the site (m/day);

K = the hydraulic conductivity of the strata (m/day);

i = the hydraulic gradient (m/m).

Dilution factors

The ***dilution factor*** can be calculated from:

$$DF = \frac{IA}{\left(Q_{gw}.\left[\frac{b_{mz}}{d_a}\right] + I.A\right)}$$

where

DF = the dilution factor (unitless);

I = the infiltration rate through the site (m/day);

A = the site area (m^2);

Q_{gw} = the groundwater flow rate beneath the site (m^3/day);

b_{mz} = mixing zone thickness (m);

d_a = the thickness of saturated aquifer beneath the site.

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1.14 Summary

The key parameters that describe contaminant behaviour in the soil zone, the unsaturated zone and saturated zone include:

- Rate of spreading (hydraulic loading);
- Chemical loading (contaminant concentration times hydraulic loading);
- Contaminant properties (solubility, partition coefficient, degradation rate, Henry's law constant)
- Soil properties (thickness, porosity/moisture content, clay content, f_{oc}, capacity for bypass flow in macropores);
- Properties of the unsaturated zone (thickness, porosity/moisture content, clay content, f_{oc}, capacity for bypass flow in fissures);
- Properties of the saturated zone (thickness, porosity, hydraulic gradient, hydraulic conductivity, mixing depth);
- Bio-chemical environment (dissolved oxygen, redox, pH) which will influence contaminant mobility and degradation.

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2 Risk Assessment (Prior Examination) Approach

2.1 Introduction

This section sets out our methodology for risk assessment (prior examination) for the discharge of waste sheep dip and pesticide washings to ground via land spreading. The general procedure is shown on Figure 2.1 which maps the path from initial (Level 1) screening assessment through subsequent levels of investigation to granting a permit or rejection.

The overall risk assessment approach follows a **source-pathway-receptor** analysis, with groundwater being the main receptor of concern. A methodology incorporates a tiered approach starting with initial qualitative Level 1 screening procedures, followed by subsequent levels of quantitative assessment (Levels 2 – 3). At successive levels, the assessment becomes less conservative, but information requirements increase. This means that information requirements are kept in proportion to the risks associated with each activity and so low-risk sites are rapidly screened out cost-effectively.

The approach incorporates 3 Levels of assessment as follows:

- **Level 1**: our initial screening procedures for assessing discharge applications for land spreading waste sheep dip and pesticide washings (see Section 2.2 and Appendix A).
- **Level 2**: a conservative quantitative assessment method (see Section 2.3).
- **Level 3**: a more detailed quantitative risk assessment (see Section 2.4).
- **Level 3 (a)**: dilution assessment (mainly for non-hazardous pollutants - see Section 2.5).

Throughout this section, the objective has been to identify a practical approach in terms of quantifying the effect of different processes on contaminant migration through the soil zone.

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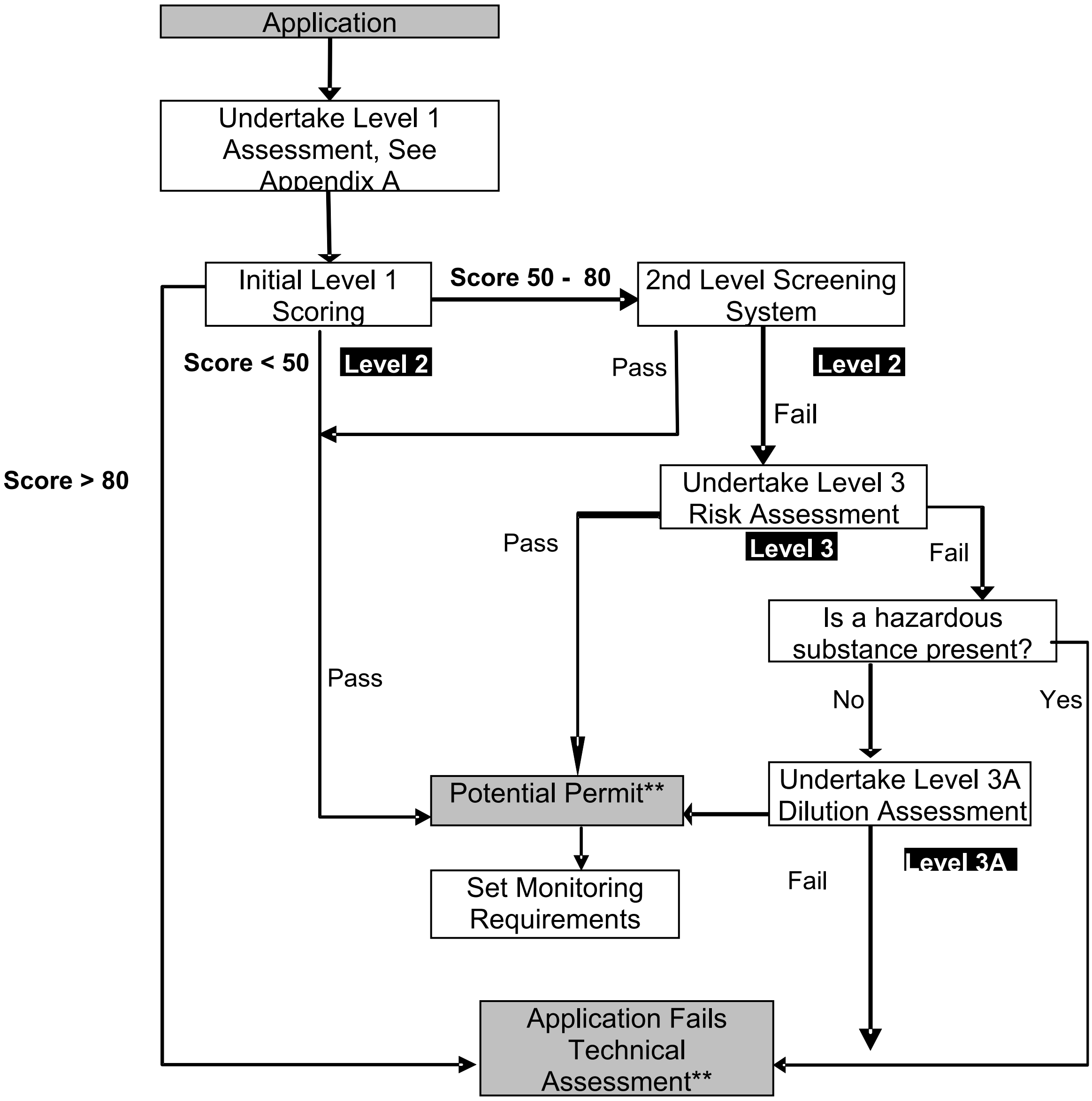
Figure 2.1 General Framework for Prior Examination



*Level 1 score thresholds are approximate
**Other factors may influence actual approval or rejection of an application, such as conservation issues

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2.2 Level 1 - Initial Screening Procedures

The aim of the Level 1 assessment is to **quickly** allocate applications into one of the categories shown in the table below:

Table 2.1 Level 1 Assessment (see Appendix A)

Category	Meaning
A	Likely to be refused. The proposed discharge is either clearly in contravention of regulations or poses such a high risk (due to location or activity) that adequate conditions could not be imposed on the groundwater activity permit to control the discharge.
B	Likely to be permitted. The proposed discharge can be adequately controlled by conditions and appropriate monitoring.
C	In a 'grey area'. They could either be permiited or refused subject to the results of further prior examination (e.g. Level 2 assessment).
Assessments that fall into categories A and B need no further detailed assessment (subject to addressing any potential conservation issues for category B's). This allows us to focus our resources on category C applications. Additionally, the Level 1 assessment procedure will help clarify what further work is needed to assess category C applications.	

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The Level 1 assessment method is based on a holistic but qualitative consideration of the following:

1. Hydraulic Loading;
2. Chemical loading;
3. Soil type based;
4. Thickness of the unsaturated zone;
5. Aquifer type;
6. Land use;
7. Toxicity of Substance mobility and toxicity;
8. Proximity to surface water or groundwater receptors.

Topography is dealt with by not allowing disposal onto slopes greater than 11°**.**

The Level 1 procedure does not quantify the fate and transport of the hazardous substance or non-hazardous pollutant to be applied. Neither does it take account of substance persistence in the soil. Instead, it qualitatively examines the general sensitivity of the site and the proposed activity.

Appendix A to this guidance sets out the detailed steps that we undertake in carrying out the Level 1 assessments for applications to discharge waste sheep dip or pesticide washings to land. The target audience for Appendix A is our permitting staff, and as such is written within the style of our internal Operational Instructions.

For applications which fail our assessment we will advise on whether relocating the discharge area to a less sensitive location could result in the application being permitted.

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2.3 Level 2 - Quantitative Screening

Introduction

To help further evaluate those applications for ***land spreading*** on soil which score in the grey area of the Level 1 screening procedure (Table 2.1), we have developed a relatively simple, conservative quantitative assessment approach. This Level 2 assessment examines whether contaminants will break through at the base of the soil zone. The methodology can also be applied to the subsoil and to a degree the wider unsaturated zone, but careful consideration will be needed of the properties for these zones. The approach however is only applicable for spreading rates of less than 30 m^3/ha/d and where no significant soil by-pass occurs. For higher spreading rates we will require a Level 3 assessment.

The method can also be used to calculate the build up of contaminants in the soil zone.

Methodology

This Level 2 assessment is based on the equations described in Section 1 to simulate contaminant movement through the soil and unsaturated zone. The development of this method is described in Environment Agency (2002).

The calculation has a number of components as shown in Table 2.2. In summary the method calculates:

- The unretarded travel time for water to travel through the soil zone assuming 'plug' or 'piston' flow;
- The retarded travel time for the contaminant. This retarded travel time is the time until the maximum concentration of contaminant leaves the base of the soil zone;
- The concentration of the contaminant at the base of the soil zone, taking account of degradation processes.

Table 3.2 – Components of Level 2 assessment method

Component	Parameters		
	Symbol	**Units**	**Description**
Risks to Groundwater			
Infiltration Rate $I = (0.1 \times AR \times N) + Inf$ *and* $Inf = (HER \times BFI)$	I_T AR N HER BFI	mm/yr m^3/ha/day No/yr mm/yr (fraction)	Infiltration rate Application rate Number of applications per year Effective rainfall[1] Fraction of HER to recharge[1]
Unretarded Travel Time in Soil $T_u = z \times \theta_w/I$	T_u z θ_w	days m (fraction)	Unretarded travel time Thickness of soil Mobile soil moisture content
Soil/Water Distribution Ratio $K_d = K_{oc} \times f_{oc}$	K_d K_{oc} f_{oc}	l/kg l/kg (fraction)	Soil/water distribution ratio Organic carbon/water distribution ratio Fraction of soil organic carbon
Retardation Factor $R_f = [1 + (K_d \times \rho/\theta_w)]$	R_f ρ	 g/cm^3	Retardation Factor Soil bulk density
Retarded Travel Time $T_r = T_u \times R_f$	T_r	Days	Retarded travel time
Total Retarded Travel Time with 'Lag' Time $T_T = T_r + T_{lag}$	T_T T_{lag}	days days	Total retarded travel time Minimum no. of days with SMD following application[2]
Attenuation Factor $AF = 0.5^{\left(\frac{T_T}{T_{1/2}}\right)}$	$T_{1/2}$	Days	Soil degradation half-life
Peak Concentration $C_{max} = C_0 \times AF$	C_{max} C_0	mg/l mg/l	Peak concentration Starting concentration applied
Soil Quality			
Mass Loaded to Soil $M_0 = 0.1 \times C_0 \times AR \times N$	M_o	mg/m^2/yr	Total mass loaded to soil per year
Mass Not Degraded in Soil $M_t = M_0 \times 0.5^{\left(\frac{365\frac{1}{4}}{T_{1/2}}\right)}$	M_t	mg/m^2/yr	Mass remaining in soil after one year (365¼days)
Residual Soil Concentration $C_r = M_t/(1000 \times z \times \rho$	C_r	mg/kg/yr	Average soil concentration after one year

1. Alternatively where infiltration rate (Inf) through the soil zone is known this can be used instead of (HERxBFI)

2.The "lag" time is for use with land spreading activities that occur only in summer months. No vertical flow is assumed when a soil moisture deficit (SMD) exists. For most assessments we conservatively assume that there is no time lag.

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Assumptions

The assumptions made by the Level 2 assessment method are given in Table 2.3. The most significant is the assumption that no soil by-pass occurs due to movement through cracks.

As part of our assessment we will review the information provided to check these assumptions are valid (e.g. no soil bypass) and that a Level 2 assessment is valid. If not we will identify that a Level 3 assessment is required.

Table 2.3 – Assumptions Made in Level 2 Assessment Method

Parameter	**Assumption**
Effective Rainfall (HER)	For year round operations, the effective rainfall following application is the maximum monthly rate, unless retarded travel time is more than two months. When retarded travel time using maximum monthly rates is closer to one year then the annual effective rainfall should be used. For retarded travel times of between two and twelve months, maximum monthly rates should be used unless conditions are imposed concerning the timing of the discharge to allow justification of annual average rates.
Runoff	No runoff during land spreading due to conditions on the permit based on slope and waterlogged nature of soils. (See infiltration below).
Infiltration	100% of HER on high vulnerability, 60% on intermediate vulnerability and 20% on low vulnerability soils based on HOST soil types. Residual becomes runoff, so separate check on wash-off potential needed.
Soil Moisture Deficit	There is no soil moisture deficit (SMD) for year round disposals. Where disposals are only in summer, a time lag can be added if the SMD exceeds the spreading rate.
Bypass flow	Bypass flow is not modelled. No bypass flow is assumed to occur during the application as a result of the low application rates. There are few firm rules controlling the likelihood of bypass flow in soils[1]. Qualitatively, there will be little or no bypass flow in unstructured sandy soils, but for finer textured and more structured soils (clay content ~>20%) the risk of bypass flow is higher. In these finer textured soils, bypass flow will be more common where soils become cracked in summer or in dry parts of the country. Bypass flow is also affected by features such as worm-holes, with worm activity likely to increase in more organic-rich soils. Once disposed material has been absorbed, bypass flow during subsequent heavy rainfall is assumed[2] to carry relatively

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Parameter	Assumption
	uncontaminated water (due to desorption kinetics).
Stones	Stones do not provide moisture or absorption sites, so it is advisable to reduce the thickness of the soil by the percentage of stones (e.g. if soil 0.2 m and stones 10%, input thickness is 0.18 m).
Soil water movement	Plug flow displacement of mobile water.
Dispersion	Dispersion is not modelled. With vertical dispersion, contaminants may break through earlier at the base of the soil at lower concentrations than the maximum predicted. Horizontal dispersion reduces maximum concentrations.
Sorption	Linear instantaneous equilibrium sorption and desorption.
Degradation	First order kinetics (degradation can be represented by half-life). Assume no acclimatisation time or concentration control on degradation.
Half-life	Safety factor of ×2 on input soil half-life to take account of lower UK temperatures compared to laboratory data or US field data.
Volatilisation	Assume taken into account in soil degradation half-life or none.

Notes:

1: The HOST Classification of soils (IoH, 1995) provides details of the likelihood of bypass flow, but this relates to the substrata and not the topsoil.

Data requirements

The data requirements in excess of those provided for the Level 1 initial screening procedure are set out in Table 2.4.

In undertaking a Level 2 assessment, detailed site-specific data should ideally be used, but as an initial screening exercise Soil Survey data can be used, provided conservative values are selected.

Table 2.5 provides conservative estimates of soil parameters based on data from Wales, but these values may not be appropriate for other areas in England. Additional information on soil types can be obtained from the database of soil information held by us or from the National Soil Resources Institute.

Table 2.5 – Default Values^{a,b} for Soil Types (in Wales)

Leaching Potential^{c}		**Depth**	**Fraction of Organic Carbon**	**Bulk Density**	**Moisture Content**	**Infiltration as % of HER**
Class^{d}	**Sub-Class^{d}**	**(m bgl)**	**F_{oc} (fr)**	**ρ(mg/cm^{3})**	**θ_{w} (fr)**	**BFI^{e}**
High	H1	0.0-0.25	0.034	1.1	0.10	100%
		0.25-0.4	0.011	1.3	0.10	100%
	H2	0.0-0.30	0.017	1.4	0.10	100%
		0.30-1.0	0.004	1.4	0.10	100%
	H3	0.0-0.25	0.026	1.1	0.10	100%
		0.25-0.7	0.006	1.2	0.10	100%
Intermediate	I1	0.0-0.25	0.021	1.3	0.15	60%
		0.25-1.0	0.005	1.4	0.15	60%
	I2		0.057	1.0	0.15	60%
Low	L		0.070	0.8	0.20	20%

Notes:

1. The soils data are from Wales and are likely to represent thin upland organic soils. Soils from other areas, such as Central England, will generally show higher bulk densities, lower organic carbon contents and lower percentages of available water capacity.
2. These default values are broadly comparable with, if less refined than, those basic soil properties
3. Leaching potential as noted on groundwater vulnerability maps.
4. Class and Sub-Class as defined on groundwater vulnerability maps.
5. Base Flow Index (BFI) from HOST data (IoH, 1995) is assumed to reflect amount of water infiltrating vertically through soil. It should also be seen as a flag for the potential of wash-off in runoff.

Table 2.4 – Additional Information Requirements and Sources for Level 2 Assessment Method

Parameter	Component	Detail Required	Sources of Information
The Activity	Type & concentration of substance (after treatment and dilution)	Contaminant/product name (e.g. diazinon, mecoprop, ammonium, cadmium) and concentration. Concentration of hazardous substances and non-hazardous pollutant's after treatment and dilution	Application Form, Sheep Dip Procedure for Working Strengths/Dilution, manufacturer, pesticide handbook etc. Targeted laboratory chemical analysis, dilution calculation.
	Other details	As for Level 1	Application Form
	Chemical properties	*Organics*: Organic partition coefficient (K_{oc}) and soil degradation half life (T½). *Others*: Partition coefficient (K_d)	Environmental Handbooks (also see Section 2.6)
Land Area	All details	As for Level 1	Application Form + OS Maps
Soils	Depth of topsoil	Estimate or measurement of soil thickness or depth to drains whichever is least.	Application Form + Site inspection*
	Bypass flow	Qualitative assessment of likelihood of bypass flow	Texture of soil (sandy soils low, clayey soils high), Wetness (wet - lower, dry - higher). Site inspection*.
	Other properties	Estimate of percentage stones and packing density, laboratory measurement of bulk density (□, moisture content (θ_w) and organic content (f_{oc}).	Application Form, Soil Maps, Soil Memoirs and National Soil Inventory, Site Inspection*. Laboratory Analysis. See Table 2.4 for default values.
Infiltration Rate	Effective rainfall	Maximum effective rainfall (HER) per month and per year, otherwise assume 200 mm/month and 1000 mm/yr.	MOSES 25 year (40 *x* 40 km) or IoH Statistics for surface water catchment area.
	Recharge rate	Free draining/high leachability (100% recharge) Moderate drainage/intermediate vulnerability (60% recharge) Poor drainage/low vulnerability (20% recharge).	Application Form details of drainage, HOST Soil Class from Soil Maps and Memoirs, Aquifer Designation/Groundwater Vulnerability Maps. Also see Table 2.4 for default values.
	Lag time	Minimum soil moisture deficit (SMD) per month for months following application, otherwise assume none.	Application Form details of time of application and MOSES 25 year (40 *x* 40 km) statistics for area.

Note: *See Environment Agency (2001f) for information which could be obtained from a site inspection.

Published HOST Class data (IoH, 1995) on baseflow indices can also be used to estimate the likely amount of hydrologically effective rainfall

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Investigations that we have undertaken indicate that where a half life of greater than 40 days has been used, this tends to result in no impact at the base of the soil zone, This assumes there is no component of soil by-pass. The use of lower degradation rate requires justification that the soil and environment conditions are appropriate. For example, laboratory scale degradation studies undertaken by ADAS for the Environment Agency (2004) have show that degradation rates with half lives of 7-17 day half life may be appropriate for diazinon in some soils.

Guidance on the use of default values, database information and site specific information is given in the box below:

Criteria	**Default Values**	**Further Data**
Application form information agrees with vulnerability maps.	As per soil type for leachability class selected.	If default values used in Level 2 assessment fail, then review values against information in relevant soils data base or use site specific data.
Site inspection shows soils different from that used in the assessment.	Adjust to appropriate values.	
Assumptions for Level 2 are invalid with respect to hydraulic loading and bypass flow.		Need site specific data to demonstrate no bypass flow at higher hydraulic loading rate.

Interpretation of results

The Level 2 tool can be used to determine:

- The retarded travel time for non- or slowly-degradable contaminants to move through the unsaturated zone;
- The predicted concentration of the contaminant at the base of the soil zone.

We use the output from the Level 2 assessment to support the evaluation of whether the proposed discharge application of waste sheep dip or pesticide washings is acceptable. The criteria for evaluating the results of the Level 2 method are set out in Table 2.6.

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Table 2.6 – Assessment Criteria for Level 2 Method

Component		**Pass Criteria**	**Comment**
Groundwater Protection			
Maximum Concentration in Water at Base of Soil Zone	C_{max}	Hazardous substances <0.01 µg/l Non-hazardous pollutants - relevant water quality standard^{a}	If fail consider seasonal constraints on land spreading. Taken as no risk of breakthrough.
		OR	
Retarded Travel Time	T_R	>100 yrs	

As there are no formal groundwater quality standards in the UK at present, site-specific standards should be determined. These standards should be based on the use of the water, natural background quality, consideration of what may constitute pollution in this instance and reference to established standards for other uses such as drinking water standards, surface water Environmental Quality Standards etc.

A worked example of the Level 2 assessment is given in Table 2.7.

Table 2.7 Level 2 Worked Example

Level 2 Soil Screening Procedure (refer to Table 2.2 for definitions of terms)

a. **Determine Input Parameters** for two discharges of 30 m^3/ha/day of 400 mg/l Chlorphenvinphos (as active ingredient) in one year to an intermediate (I2) vulnerability soil of 0.3 m thick.

Parameter	Input Value	Source	
Chlorphenvinphos Disposal			
Starting concentration (C_0)	400 mg/l	See above	
Partition Coefficient (K_{oc})	374 l/kg	Vogue (1994)	
Degradation Rate ($T_{½}$)	7 days × 2*	Vogue (1994)	* Safety factor
Application Rate (AR)	30 m^3/ha/d	See above.	
Number of Applications (N)	2 per year	See above.	
Soil			
Soil thickness (z)	0.3 m	See above.	
Soil moisture content (θ_w)		15% = 0.15	Table 2.5 - I2 Soil
Soil bulk density (□	1.0 g/cm^3	Table 2.5 - I2 Soil	
Soil organic content (f_{oc})	0.057	Table 2.5 - I2 Soil	
Soil base flow index (BFI)		60% = 0.6	Table 2.5 - I2 Soil
Climate			
Effective rainfall (HER)			
-Maximum monthly	200 mm/month	Default assumed	
-Average annual	1000 mm/yr	Default assumed	

b. **Calculate infiltration rates**

Infiltration Rate(I) is *(0.1 × AR × N) + (HER × BFI)*, so:

-maximum monthly $(0.1\times30\times2)+(200\times0.6) = 126$ mm/month

$= 1.512$ m/yr

-average annual $(0.1\times30\times2)+(1000\times0.6) = 0.606$ m/yr.

c. **Calculate retardation factor** for the soil zone.

$R_f = 1+(K_{oc}.f_{oc}.\rho/\theta_w) = 1+(374\times0.057\times1.0/0.15) = 143$ (no units).

d. **Calculate unretarded travel time** for the soil zone using monthly infiltration rate.

$T_u = z.\theta_w/I = 0.3\times0.15/1.512 = 0.0298$ yrs $= 10.9$ days.

e. **Calculate retarded travel time** for the soil using monthly infiltration rate.

$T_r = T_u \times R_f = 0.0298\times143 = 4.26$ yrs

As retarded travel time is > 1 year, recalculate Steps ‘d’ and ‘e’ using annual infiltration rate of 0.606 m/yr to give revised T_u of 27.1 days and revised T_r of 10.63 yrs or 3883 days.

f. **Determine period of SMD** (T_{lag}) dependent on timing of application. If application occurs all year, use T_{lag} = 0. (assumed 0 here).

g. **Determine total retarded travel time**

$T_T = T_r + T_{lag}$ (T_T = 3883 days + 0 days) = 3883 days or 10.63 yrs

h. **Calculate attenuation factor:**

$$AF = 0.5^{\left(\frac{T_T}{T_{½}}\right)} = 0.5^{\left(\frac{3883}{14}\right)} = 3 \times 10^{-84}.$$

i. **Calculate contaminant concentration** at base of the soil zone as follows:

$C_{max} = C_0 .AF = 400 \times 3 \times 10^{-84} = 1 \times 10^{-81}$ mg/l **=** below detection.

Uncertainty Analysis

To illustrate the sensitivity of these calculations to soil type, the I2 soil properties have been replaced with those of an H2 soil and the calculations repeated. This gives the following results for comparison:

Parameter	**I2 Soil**	**H2 Soil**
Total Retarded Travel Time (yrs)	10.63	2.68
Contaminant concentration at base of soil (mg/l)	1×10^{-81}	3×10^{-19}

Assessment of results

The calculated concentration of the pesticide at the base of the soil zone is significantly below minimum reporting value (0.01 ug/l), therefore this Level 2 assessment indicates that the discharge would be acceptable.

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If the acceptance or rejection of the application is marginal then we will examine the data used to define key parameters to determine whether these have been adequately defined. This assessment is likely to include uncertainty analyses to determine how key parameters may affect the result.

For applications which are marginal or have failed we may ask you to undertake a Level 3 assessment. (Section 2.4).

The tool can also be used to calculate the concentrations of substances within the soil zone and whether therefore provides a means to support an assessment of whether residual concentrations are significant.

We have undertaken groundwater sampling downgradient of permitted sites to check whether the activity has impacted groundwater quality. This sampling has identified that the Level 1 and 2 assessment tools are conservative, unless significant by-pass flow occurs.

Scoping options for applications failing at Level 2

For those applications which fail this Level 2 assessment, guidance on possible options is provided in Table 2.8. Additional notes associated with the table are given below. It is noted that options 1 to 3 in Table 2.8 are also open for applications failing at Level 1.

Table 2.8 – Options for Applications Failing at Level 2

Option	Description	Additional Data Requirements	Sources of Information
1	Use an alternative area for spreading or increase area to reduce hydraulic loading.	As per Level 1 & 2 for new area	As per Level 1 & 2 for new area
2	Consideration of reduced loading, pre-treatment or dilution before discharge.	Proposed and approved method and effect of treatment and dilution on chemical loading.	Applicant, product manufacturer.
3	Use of a different pesticide or sheep dip chemical.	Chemical properties of new substance.	As for Level 2.
4	Use site specific information for soil properties, such as f_{oc}, K_d, if application fails using default values. The Level 2 tool could be used to assess the sensitivity to these parameters before data collection. The key soil parameter for organic (hydrophobic) contaminants is the fraction of organic carbon.	Site specific data for e.g. f_{oc}, K_{oc}, *pH*, K_d. Also bulk density and moisture content.	Field/lab measurement of *pH*, otherwise soil sampling and laboratory measurements or strong case put on the basis of literature data.
5	Demonstration of more rapid soil degradation half-lives (see Notes for method of calculating half-life).	Laboratory tests (new sites) or (see note in text) application history and soil concentration for existing sites.	Site's soil & applied contaminants Applicant's records and laboratory analysis of site's soils.
6	Consider the potential attenuating capacity of the unsaturated zone using the Level 2 tool (see Notes).	Depth to water table. Nature and likelihood of bypass flow. f_{oc} (typically <0.1%), Moisture content, bulk density, K_d based on pH.	As for Level 1 HOST Class subdivision based on substrate. Borehole logs/geological maps for nature of strata, then literature such as LandSim, ConSim , and Aquifer Properties Manuals.
7	Carry out a more detailed quantitative risk assessment (Level 3) which for non-hazardous pollutants may include dilution (Level 3a)	See Section 3.4	See Section 3.4

Notes: (on next page)

Notes for Table 2.8

Note 1 (for Option 5):

The soil half-life could be determined by measuring the soil concentration now (see Environment Agency 2000g for soil sampling protocol) and determining the chemical loading to the soil. It is calculated by:

$$T_{½} = \sqrt{\frac{0.693.t}{\ln\left(\frac{M_0}{M_t}\right)}}$$

where:

$T_{½}$ is the calculated soil degradation half-life (days).

t is the time elapsed since the last application (days).

M_0 is the concentration applied to the soil ($mg/m^2/yr$) (see Table 3.2 for derivation).

M_t is the concentration remaining in the soil ($mg/m^2/yr$) (see Table 3.2 for derivation).

ln is the natural logarithm.

Care must be made when using this method that the concentration in the soil is not low due to excessive leaching to groundwater.

Note 2 (for Option 6)

In the unsaturated zone, levels of organic carbon are likely to be significantly lower (10 to 100 times) and degradation rates are likely to be similarly lower than in the topsoil and so attenuation is likely to be low for hydrophobic contaminants with slow degradation rates. This means that it is unlikely to be worthwhile undertaking unsaturated zone calculations for these contaminants if this zone extends for less than 2 m below the base of the soil zone.

However, unsaturated zones may provide a significant attenuation capacity for some inorganic contaminants (e.g. ammoniacal nitrogen and metals) due to different conditions (compared to the overlying soil) of e.g. pH or CEC and, for rapidly degrading organics (e.g. phenols), due to relatively long travel times for the water where infiltration is low and moisture contents are significant. For example, for 2 m of unsaturated fine sands with a moisture content of 10%, plug-flow of 200 mm/yr infiltration would take 1 year.

For the unsaturated zone it is also important to assess the likelihood of bypass flow. This can be done using the HOST Class system (IoH, 1995).

For degradable contaminants, the safety factor for the degradation half-life in the unsaturated zone should be increased from ×2 for soils to ×4 to accommodate for the lower microbial population. This doubling of the soil degradation half-life is consistent with the approach taken by Howard (1991, page xviii) to differentiate between rates in soils and in groundwater. Both the ×2 and ×4 factors may require subsequent revision based on research and monitoring results.

To calculate a combined (soil plus unsaturated zone) attenuation factor then the soil zone attenuation factor should be multiplied by that estimated for the unsaturated zone. Should this total attenuation factor allow the activity to meet the acceptance criteria in Table 3.6, then it will be necessary to validate the unsaturated zone properties used including the risk of bypass flow.

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2.4 Level 3 Detailed quantitative risk assessment

Introduction

The Level 3 assessment is intended to provide a more detailed assessment of contaminant movement through the soil, the subsoil and unsaturated zone. Level 3 will require development and support of a conceptual model of contaminant behaviour and collection of site specific data. It is also likely to involve the use or development of a more sophisticated, probably probabilistic model than previously used.

This guidance does not describe the quantitative risk assessment methods that could be used for the assessment of land spreading, but rather describes the approach that should be adopted and to reference relevant methods. You should also read the general requirements for a groundwater risk assessment as outlined in Annex (j) Groundwater. It is recommended that you should enter in discussion with us prior to undertaking any work.

Due to the site investigation and/or consultancy costs of undertaking a Level 3 assessment, it is likely that only a few of the larger applications will progress to this stage. Most, if not all, waste sheep dip and pesticide washings applications should be determined via the Level 1 and / or 2 assessment approaches.

For non-hazardous pollutants dilution by groundwater below the discharge area can also be considered as part of a Level 3 assessment (Section 2.5). Dilution can be considered for hazardous substances in the context of the meaning of "prevent" as noted in Box 1.3. It is a prerequisite that long term monitoring of groundwater immediately down-gradient of the discharge is in place for this to be considered, which in most instances of waste sheep dip and pesticide disposal will not be the case.

Why a Level 3 assessment may result in approval of application

A Level 3 assessment may confirm that the application is **unacceptable** and you should bear this in mind when considering costs. A proposed discharge that is acceptable at Level 3 may also require significant monitoring (e.g. of the soil or unsaturated zone) as part of the permit (Section 4). Given these warnings, you should identify the reasons why an application failing Level 2 may be successful at Level 3.

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The Level 2 assessment is a conservative approach for assessment of land spreading activities. In particular, it does not consider:

- Mixing (through hydrodynamic dispersion) of the discharged volume of contaminant with rainfall infiltrating down through the soil column. This will reduce contaminant concentrations;
- Desorption kinetics - this could lead to a slower release of contaminants from the soil to the water and thus less impact at the water table;
- Volatilisation, hydrolysis and microbial degradation separately - this could lead to greater losses from the soil than predicted by the Level 2 soil-degradation half-life;
- Attenuation in the unsaturated zone below the soil zone;
- Dilution by mixing with groundwater below the discharge area.

The Level 2 assessment is based on the conservative input values and the use of a probabilistic approach may improve confidence in the acceptability of the proposed discharge.

A range of models may be applicable to a Level 3 assessment, ranging from excel based spreadsheets through to soil leaching models. The use of these models will need to be supported by additional data collection and justification of the choice of model (Environment Agency 2001a).

Examples of the types of more sophisticated soil leaching model that may be appropriate for a Level 3 assessment are PESTAN and MACRO (Environment Agency, 2002 and Jarvis, 1995) that provide a more detailed assessment of contaminant movement in the soil and unsaturated zone. In each case it is important that the assessor has the requisite skills and experience to use these tools.

A critical assumption in the Level 2 assessment is that there is a low risk of bypass flow through the soil and unsaturated zone. Where such flow occurs then a Level 2 assessment is not valid and an alternative Level 3 assessment will be required to determine whether bypass flow could result in an impact on groundwater.

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In the case the assessment will need to based on models that incorporate by-pass flow. Example of such models include MACRO and PRZM (see Environment Agency 2002). These models require a lot of site specific data, time and expertise to use and therefore consideration should be given to whether it may be more appropriate to relocate the disposal area.

As for the options for applications failing at Level 2 (see Table 2.8 and its accompanying Note 2), consideration of the attenuation in the unsaturated zone at Level 3 is only likely to be worthwhile where this zone is thicker than about 2 m. There may be exceptions for some contaminants e.g. for metals where the chemical conditions (e.g. pH) are markedly different to the soil zone or, for highly degradable contaminants, in areas where infiltration rates are low (drier parts of the country or beneath low permeability soils).

For many sites and contaminants, the ***soil*** will provide the most attenuation (particularly for hydrophobic organic chemicals) and so the focus will be on more accurately simulating:

- Water transport in soil micropores and macropores at high rates of hydraulic loading and rainfall. This could require more detailed climatic data;
- Contaminant partitioning between air, water and the soil in macropores and micropores;
- Degradation processes in the soil.
- For other sites, where the soil is thin, has low organic carbon or the contaminants are hydrophilic organics or inorganics, the focus may be on:
- Water transport in micropores, macropores and fissures within the subsoil and unsaturated zone;
- Partitioning and chemical reaction in the unsaturated zone.

The advantage of representing processes in greater detail will be to have greater confidence in their importance and then be able to use less conservative assumptions and input parameters.

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Overall procedure for Level 3

Each Level 3 assessment will be site specific, but the general procedure should be as follows:

1. Define conceptual model in terms of:
    - Physical description of topsoil (and if necessary), subsoil and unsaturated zone including likelihood of bypass flow;
    - Processes that affect contaminant transport e.g. volatilisation, sorption, degradation;
2. Select/develop approach or computer code;
3. Identify model input parameters and data sources;
4. Agree pass/failure criteria with us;
5. Undertake the investigation;
6. Undertake uncertainty analysis;
7. Assess need and cost of obtaining additional site investigation or monitoring data for key input parameters;
8. Determine if concentrations at; base of soil zone, or (if necessary) at base of subsoil, or at base of unsaturated zone are acceptable;
9. Determine if monitoring requirements are to be attached to the permit and the nature of these.

For guidance can be found in Environment Agency (2001a, b and c).

Additional data requirements for Level 3 assessments

The data requirements for Level 3 assessments will be site specific, but Table 2.9 provides sources of information for those parameters that may be considered. It is assumed at this stage that we have sufficient data to have met the information requirements of Levels 1 and 2.

Interpretation of Level 3 results

The criteria for assessment of Level 3 results are the same as those at Level 2 (see Table 2.6) with the compliance point at the water table, beneath the disposal site (in the case of non-hazardous pollutants a mixing zone and dilution factor can be used - see Section 1.13).

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Options for applications failing Level 3

These will be as for Level 2 Options 1-3 (different land area, treatment and dilution or use of a different chemical) and a Level 3a assessment may be applicable for non-hazardous pollutants or for hazardous substances where exemptions apply or the tests for “prevent” can be assessed (Box C).

2.5 Level 3a Dilution Calculations

For non-hazardous pollutants dilution by groundwater flow below the discharge area can be routinely taken into account in the assessment of whether the discharge is acceptable. For most land spreading discharges of waste sheep dip and pesticides washings, the assessment will be driven by hazardous substances and the dilution calculations will generally not be required for the reasons noted in section 1.13 (i.e. the assessment will first need to demonstrate the there will not be a breakthrough of a hazardous substance at the base of the unsaturated zone).

The concentration of a non-hazardous substance in groundwater can be calculated as illustrated in Table 2.9 based on the ratio of groundwater flow below the disposal area and infiltration over the disposal area (see Section 1). For the discharge to be acceptable the calculated concentration should be below the compliance concentration which will be typically be an environmental standard.

Table 2.10 Dilution Calculation.

The concentration of a pollutant in groundwater can be calculated from the following equation:

$C_{gw} = C_{max}/DF$

Where

C_{max} = Concentration at base of unsaturated zone or conservatively from the base of the soil zone.

DF = Dilution Factor

The dilution factor can be calculated using the equations given in Section 1.13.

Table 2.10 – Possible Additional Information Requirements and Sources for Level 3 Assessment

Parameter	Component	Detail Possibly Required	Sources of Additional Information
The discharge	Type and concentration of substance (after treatment and dilution)	As for Level 2	As for Level 2, but with targeted laboratory chemical analysis of sample collected by our staff or independent consultant to confirm the concentrations of different substances to be applied.
	Other details	Demonstration of effect of method of application on hydraulic loading rate.	Site specific study or Agency R&D.
	Chemical properties	Site specific information on soil or rock/water partition coefficients (K_{oc} and K_d) and soil degradation half life(s).	Soil profiles in National Soil Inventory. Laboratory batch tests, column tests or lysimeter trials. Also degradation rate tests such as soil incubation studies. BOD tests for microbial activity and determination based on existing soil concentrations and application history (see Note 1 for Table 3.8).
Land Area	All details	As for Level 1.	As for Level 1.
Soils	Depth of topsoil	The lesser of soil thickness or depth to drains.	Multiple measurements (augering or use of spade) of depths.
	Macroporosity	Determination of importance of macroporosity and microporosity on contaminant movement.	Estimates of the volume of pores >60 µm in diameter from laboratory measurement of particle size distribution and estimated packing density. Also estimated from retained and available water content (Soil Survey, 1984).
	Other properties	Site specific measurement of bulk density (ρ, moisture content (θ_w), organic content (f_{oc}). Also saturated hydraulic conductivity.	Site inspection by a soil scientist. Also sampling and laboratory determination.

Table 2.10 (continued) – Possible Additional Information Requirements and Sources for Level 3 Assessment

Parameter	**Component**	**Detail Possibly Required**	**Sources of Additional Information**
Infiltration Rate	Effective rainfall	Maximum effective rainfall per month and per year or on a daily basis.	MOSES 25 year (40 *x* 40 km) statistics or site specific calculation of effective rainfall using Met Office rainfall and climatological data or site specific weather station data.
	Infiltration/recharge rate	Maximum saturated vertical hydraulic conductivity or moisture content	Visual inspection by soil scientist for likely Soil Series and HOST Class. Saturated hydraulic conductivity estimate for coarse textured soils using particle size distribution (BS 1377) and assumption of porosity. Recharge rates based on calibrated groundwater flow models. Field infiltration tests (double ring infiltrometer), lysimeters, pore water profiling or determination of water flux from neutron probes.
Unsaturated Zone (rock)	Thickness	Depth to maximum water table elevation.	Existing representative borehole logs near (and sufficiently close to be representative) within 500 m of site or site investigation by trial pitting (<~6 m in unconsolidated strata) or drilling.
	Degradation Rate	Justification for degradation rate in unsaturated zone.	Literature data for similar conditions elsewhere. (For an existing site) calibration of rate using site monitoring data if available.
	Other Properties	Site specific measurement of bulk density (ρ, moisture content (θ_w), organic content (f_{oc}). Also saturated hydraulic conductivity.	Existing representative borehole logs near (and sufficiently close to be representative of the) site then use of Aquifer Properties Manual(s), LandSim or ConSim (Environment Agency 2007a and 2007b). Site Investigation by trial pitting (<~6 m in unconsolidated strata) or drilling, collection of undisturbed (U100) samples and soils description to BS5930. Sampling and laboratory determination including laboratory

.

Technical Annex to Annex (j) – Prior examination for discharges to land of waste sheep dip & pesticide washings

3 Monitoring

3.1 Introduction

This section describes our requirements for monitoring permitted discharges of waste sheep dip and pesticide washing. We will not permit a discharge without first ensuring that appropriate arrangements are in place for monitoring of the activity and, where necessary, for requisite surveillance of groundwater.

Monitoring is used in this section to describe the general monitoring requirements that are necessary to ensure that a permit complies with EPR 2010, including monitoring of the discharge, and any additional monitoring to determine if the discharge impacts on groundwater, and particularly its quality.

Requisite surveillance is used in this section to refer specifically to the monitoring of groundwater (as indicated in EPR 2010) and is only part of the monitoring activity that is necessary to ensure that a permit complies with the requirements of the Regulations. For example, if monitoring of soil and/or the unsaturated zone is to be carried out, this should be under the general requirements for monitoring of the permit rather than the heading of "requisite surveillance".

Monitoring that we may require you to undertake (Section 3.2) may include one or more of the following:

- **Record keeping**. This is a requirement of all permits;
- **Monitoring of the discharge**. This will be dependent on the activity and associated risk;
- Monitoring (**requisite surveillance**) of groundwater (e.g. boreholes) or groundwater discharges (e.g. springs, river baseflow). This will also be dependent on the activity and associated risk.

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In addition as part of enforcement of the permit we may undertake (Section 3.3) the following:

- **Site visits** to verify details of the application and compliance with the technical measures required by the permit including record keeping;
- **Defensive monitoring** of groundwater (e.g. boreholes) or groundwater discharges (e.g. springs, river baseflow). The objective of this monitoring is to provide confirmation that the overall assessment process is appropriate (i.e. protects groundwater from the discharge of pollutants).

3.2 Monitoring as part of the Conditions of the Permit

This section provides further details of the monitoring we may require you to undertake.

Monitoring and record keeping

The objective of this exercise is to quantify the rate of discharge and the quality of the discharge, to demonstrate that the conditions of the permit are being met and that the information used in the assessment of the activity is appropriate.

Monitoring should include:

- **Either** recording chemicals used and their concentration (this would normally be based on providing specific details of chemicals from packaging information);
- **Or** chemical analysis of the discharge, if the composition of the waste cannot be readily determined (e.g. from packaging information);
- Recording of the undiluted and diluted volume of waste sheep dip or pesticide washings discharged of, together with the method of disposal;
- Recording the area of spreading on a map, together with the number and date of each application.

You should maintain appropriate records and make these available for inspection by our officers to determine compliance with the conditions of the permit.

Technical Annex to Annex (j) – Prior examination for discharges to land of waste sheep dip & pesticide washings

Soil and unsaturated zone monitoring

We may require you to undertake monitoring of the soil or unsaturated zone where a Level 2/3 assessment has been undertaken **and** some uncertainty still exists that the discharge could result in the input of hazardous substances to groundwater and/or pollution by non-hazardous pollutants

In such cases, we will only grant a permit if you agree to monitoring of the soil and/or unsaturated zone as part a condition of the permit. This might include obtaining soil samples from the discharge area for laboratory analysis. Box 3.1 provides details of our recommended approach for soil sampling.

Such monitoring may be required, for example, where our Level 2 assessment identifies that the calculated delay for migration to the water table is greater than 10 years and we want to check the assumptions in our risk assessment.

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Box 3.1 Soil Sampling

Studies that we have undertaken on waste sheep dip disposals has shown that soil sampling from the discharge area is likely to provide a suitable, cost effect method of sampling.

The general procedure for soil sampling is outlined below:

- Assess the surface of the disposal area for evidence of cracking, waterlogging etc – it is a condition of each permit that the discharge does not occur on cracked, frozen or waterlogged ground;
- Obtain sample using either a soil auger or from a hand dug pit;
- Record thickness and description of each soil layer. This should include a note on the colour, friability and plasticity of the soil as well as the presence or absence of cracks, open wormhole structures etc.;
- Where the potential for bypass flow is suspected, soil samples should be collected from the base of the subsoil zone. The justification for this is that if contaminants are detected at the base of the subsoil zone (after ~14 days) then it is likely that by-pass flow of contaminants has occurred, and the disposal potentially presents a higher risk of impacting upon groundwater;
- Where non-conservative degradation rates have been assumed the focus of the sampling is on checking whether the pesticide or waste sheep dip has degraded in the top soil (top 10 cm) to the low concentrations predicted;
- The number of samples collected should reflect the overall risk at a particular disposal site. For higher risk sites, a minimum of three locations should be targeted and in each area three samples collected from the appropriate depth (top 10 cm for non-conservative degradation rate use and base of subsoil where there is a perceived risk of bypass flow). These area samples should be combined to form a mixed sample at each of the three locations. At sites where the perceived risk is less, three samples from across the disposal area could be combined to provide a single composite sample for analysis;
- Soil samples should be analysed for:
  - The relevant active ingredients in sheep dip (e.g. diazinon and other sheep dip products). Consideration should also be given as to the benefit of analysing a potential metabolites;
  - Moisture content, bulk density, pH and Foc.

Technical Annex to Annex (j) – Prior examination for discharges to land of waste sheep dip & pesticide washings

Requisite surveillance of groundwater

In general, it is unlikely that we will require surveillance of groundwater (i.e. borehole monitoring) for the majority of land spreading applications as the assessment procedure has been designed to screen out activities that would give rise to a risk of the discharge of hazardous substances at the water table or of pollution by groundwater from non-hazardous pollutants.

For each application, however, we will assess whether requisite surveillance is required in addition to potential monitoring of the discharge (where specified as part of the permit) and to site inspection.

The factors that we would consider in deciding whether or not requisite surveillance is required are:

- The results of the Level 1 assessment procedure. In general, for applications where the score is within the low risk category, no impact would be expected and groundwater monitoring will not be required. For a higher risk category site, requisite surveillance will be considered, **unless** further assessment (Level 2 to 3), confirms that no impact on groundwater would be expected;
- The delay for contaminants to migrate through the soil and unsaturated zone, particularly where the travel time through the unsaturated zone exceeds 10 years. In some cases, we consider that monitoring of the soil or unsaturated zone is more appropriate;
- The likelihood that any impact could be detected (i.e. where the proposed rate of discharge is sufficiently small in relation to groundwater dilution such that any Hazardous substances and/or non-hazardous pollutants would not be detectable);
- The practicality and cost of implementing a groundwater monitoring scheme;
- The nature of the activity and whether there is a risk of hydraulic overloading of the soil or unsaturated zone, resulting in rapid transport to the saturated zone (e.g. spreading rates greater than 30 m^3/ha/d);

We will discuss the requirements for monitoring with you as part of the permitting process.

Technical Annex to Annex (j) – Prior examination for discharges to land of waste sheep dip & pesticide washings

3.3 Compliance Monitoring

Site visits

As part of enforcement of the permit we will carry out periodic reviews / site visits with the objectives of:

- Check that the information provided in the application is correct (e.g. verification of spreading area, soil type for land spreading activities);
- Confirm that the activity meets the requirements of the permit, including record keeping and that all necessary technical precautions to protect groundwater and surface water are in place;
- Identify whether site practices comply with relevant statutory codes of practice (e.g. storage of chemicals);
- Confirm that the activity or site operations do not represent a risk to groundwater and surface water (e.g. the discharge area is not located near to a spring, borehole or watercourse);
- Identify possible alternative options for the activity (e.g. alternative areas of spreading), if subsequent reviews of the activity conclude that it represents an unacceptable risk to groundwater or surface water;
- Identify if additional investigation is warranted (e.g. soil testing if site inspection finds that the soil conditions differ from those used in assessment).

The **frequency of reviews / site visits** for all groundwater activity permits discharging waste sheep dip or pesticide washings should be at least once during a 6 year period. For higher risk sites and greater volumes then the frequency of our site visits will increase.

Supplementary defensive monitoring

For the majority of permits requisite surveillance is unlikely to be necessary as the assessment procedure has been designed to screen out activities that could represent a risk to groundwater. However, as part of the site visit and review of the activity, we will consider whether sheep dip, soil and or groundwater monitoring should be undertaken (i.e. there is a concern that the disposal could impact groundwater) either by using an existing borehole or by constructing a new monitoring point.

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Groundwater monitoring can represent a relatively expensive option, particularly if a new monitoring point is located. Sampling from existing boreholes and springs represents an order option, but there must be confidence that this monitoring point is located down-gradient and within 50m (Principal Aquifers) or 250m (Secondary Aquifers) from the discharge area.

3.4 Assessment of monitoring results

Based on our review of the site records and site visit, the following actions may arise:

- The permit is appropriate and the conditions have been met by you;
- The assessment of the activity needs to be revised (for example, soil conditions differ to those given in the application), leading to higher or lower score under the screening system. For significantly higher scores, then:
    - The permit may need to be assessed using Level 2 or Level 3 methods and subsequently may either need an increased amount of monitoring, modification to the conditions on the permit, or even that it needs to be revoked as it may be giving rise to pollution;
    - The activity may need to be modified (e.g. reduced rate of spreading, or moved to a lower risk area);
    - Further investigation (including soil sampling) may be necessary.
- Enforcement action due to non-compliance with the conditions of the permit. Unless you agree to modify site practices, the permit may be revoked;
- Additional monitoring of the discharge needs to be implemented by you as, for example, there is uncertainty regarding the nature of the discharge (you have not been unable to provide adequate records on the discharge);
- Monitoring of groundwater (well/borehole) or groundwater discharge needs to be implemented by you, particularly if the your water supply is located near to the point or area of discharge;

The basis for us requiring additional investigation following a site inspection should be:

- Site visit indicates that the soil is of different character (higher leaching potential) from that determined by the applicant or from examination of soil survey or groundwater vulnerability maps/datasets, and where the permit may need to be modified or revoked unless an assessment based on site specific data shows that the activity is acceptable;

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- Site inspection confirms that the soil is shallow or is of high leaching potential, such that a site specific assessment is required to confirm that the activity does not present a risk to groundwater;
- Inspection of site discharge/disposal arrangements indicate that the soil zone is being bypassed and there is reliance on the unsaturated zone, data for which are not available.

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Appendix A: Level 1 assessment method for groundwater activity permit applications discharging used sheep dip/pesticide washings to land

What is this Appendix about?	This appendix details how we undertake prior examination (Level 1 assessments) in order to determine groundwater activity permits applications under the Environmental Permitting (England & Wales) Regulations 2010, for the discharge of used sheep dip or pesticide washings to land. It also can be applied, where necessary, to reassessments of existing groundwater activity permits following reviews.
Who does it apply to?	Staff within the National Permitting Service (NPS) responsible for undertaking Level 1 assessments, under the Environmental Permitting Regulations 2010 (EPR 2010).

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Technical Annex to Annex (j) – Appendix A

Level 1 assessments and scoring

Introduction

Purpose This section explains what a prior examination (at Level 1) assessment is and how it is performed. It shows how the scoring system works and how the scores are used to determine a permit application or where a reassessment (at Level 1) is required, following review. It also highlights where a further, more detailed investigation/risk assessment is required, and who should do them.

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Level 1 assessments

Categorising applications

The aim of the Level 1 assessment is to **quickly** allocate applications into one of the categories shown in the table below:

Category	Meaning
A	Likely to be refused. They are either clearly in contravention of regulations or pose such high risk (due to location or activity) that adequate conditions could not be imposed on the groundwater activity permit to control the discharge.
B	Likely to be permitted. These can be adequately controlled by conditions and appropriate monitoring.
C	In a ‘grey area’. They could either be permiited or refused subject to the results of further prior examination.
Assessments that fall into categories A and B need no further detailed assessment. This allows us to focus our resources on category C applications. Additionally, the Level 1 assessment procedure will help clarify what further work is needed to assess category C applications.	

How Level 1 assessments work

Level 1 assessments use a semi-quantitative scoring system. However, **common sense must be applied at all times** and any deviations from the method recorded in the application file for future reference.

The Level 1 assessment adopts a risk based, source-pathway-receptor approach. However, the source is a closely defined activity (the discharge of the hazardous substance chemicals used in sheep dip and/or pesticide washings), and the receptor is the groundwater **below the discharge site.** Thus any risk assessment concentrates on the source term and the effectiveness of the soils and unsaturated zone.

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Take the wider picture into account

The framework document takes account of both the requirements of EPR 2010 and our more general duties, such as the requirement to comply with the Habitats Directive. The Level 1 assessment must not, therefore, be viewed in isolation. Our wider responsibilities have been taken into account in its derivation, including the need to have regard to:

- protection of surface waters;
- the possible impacts on other wetland ecosystems;
- existing statutory codes of practice (CoP);
- the possibility of long term soil contamination;
- the Habitats Directive and other conservation interests;
- the Landfill Directive.

Factors considered

Several factors are considered in the Level 1 assessment. They are categorised as either Group I or Group II factors. The table below lists these and indicate which are Group I and which are Group II:

Factor	Group I	Group II
Hydraulic loading	☐	
Chemical loading	☐	
Unsaturated zone thickness	☐	
Proximity to other receptors	☐	
Soil type	☐	
Aquifer (geology)	☐	
Land use	☐	
Substance mobility/toxicity	☐	
Nature conservation status		☐
Soil under drainage		☐
Group I factors are used in the scoring system and can be derived readily from a completed application pack and our own held data. It is considered inappropriate to score Group II factors. Group II factors are addressed within flowcharts and also via conditions on the permit. In the case of conservation status, third parties may need to be consulted.		

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Group I scoring

How the scoring works

For each Group I factor, an initial assessment of the potential risk is made and a score assigned to bands for each of these factors. Scoring is broad and for some categories only 'high', 'medium' and 'low' risk bands are necessary. Individual factor scores are then summed to produce an overall Level 1 screening score (see table below).

Scoring bands and what they mean

If the Level 1 screening score is:	then the proposed discharge is:
≥80	unacceptable: the application (or review) is a candidate for refusal.
50-79	in the grey zone: the application requires further consideration/prior investigation.
<50	acceptable: the application can proceed.

Note: Whilst a Level 1 screening score of 50-79 is technically within the 'grey zone', this does **not** necessarily mean that a Level 2 assessment is automatically required. See Interpreting the scores for more details.

Unacceptable or high risk bands

For some factors, an 'unacceptable or very high risk' band has been defined, where it is known that an activity within the band is in direct contravention of EPR 2010 or which would exceed the limits set within established CoP. The upper bands have been assigned a score that would either automatically place the proposed discharge in, or close towards the 'very high risk' category, so that only a couple of 'high risk' scores would make the application a candidate for potential refusal.

Technical Annex to Annex (j) – Appendix A

Performing the assessment

Introduction

Purpose This section explains how to undertake the Level 1 assessment.

Contents

The overall process

Summary A summary of the overall Level 1 assessment process is highlighted in charts 1 – 3.

Chart 1 Begin here. That is, once an application has been received.

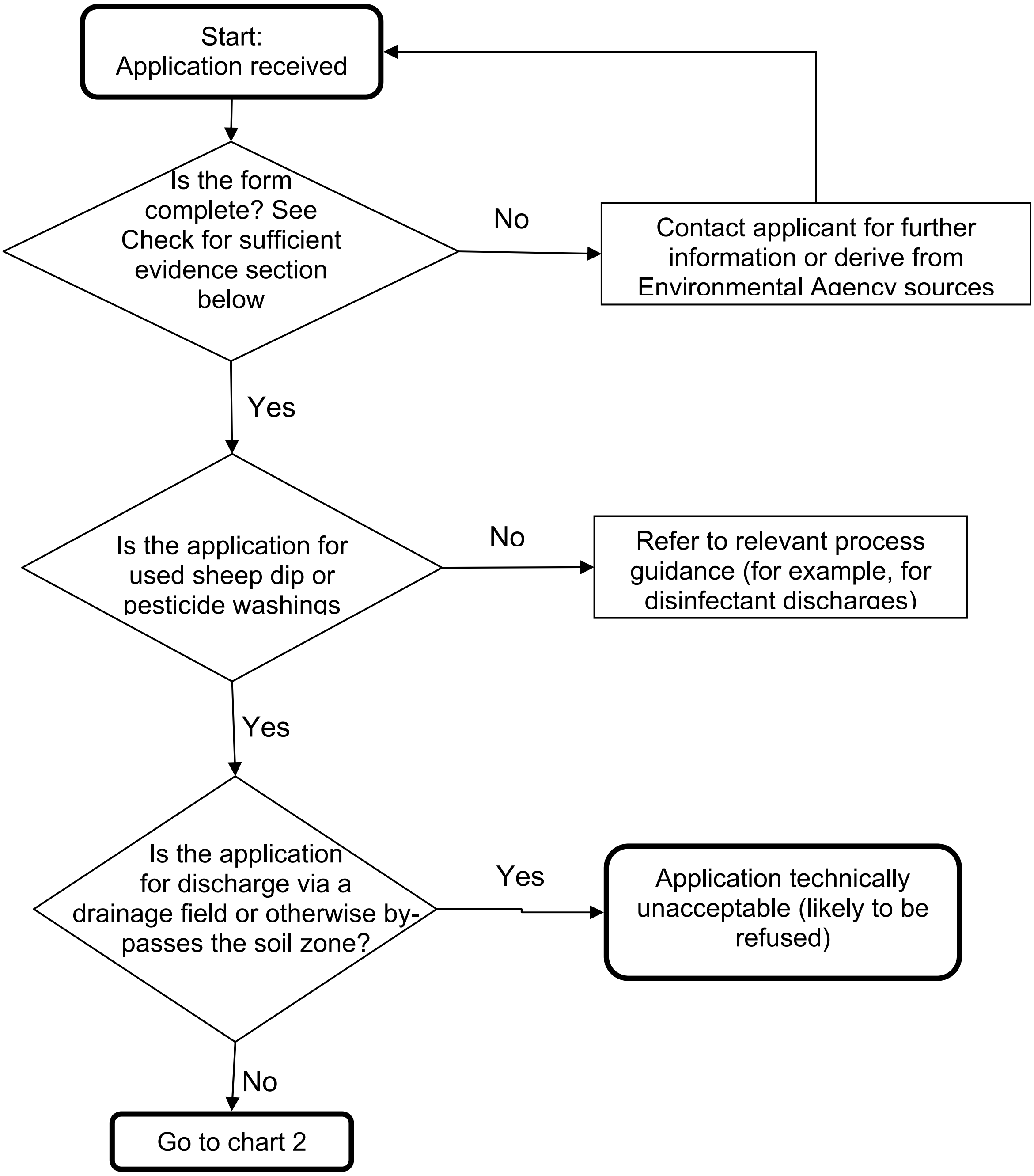


Chart 2 Continue here if the application for discharge is not via a drainage field or otherwise by-passes the soil zone (from chart 1).

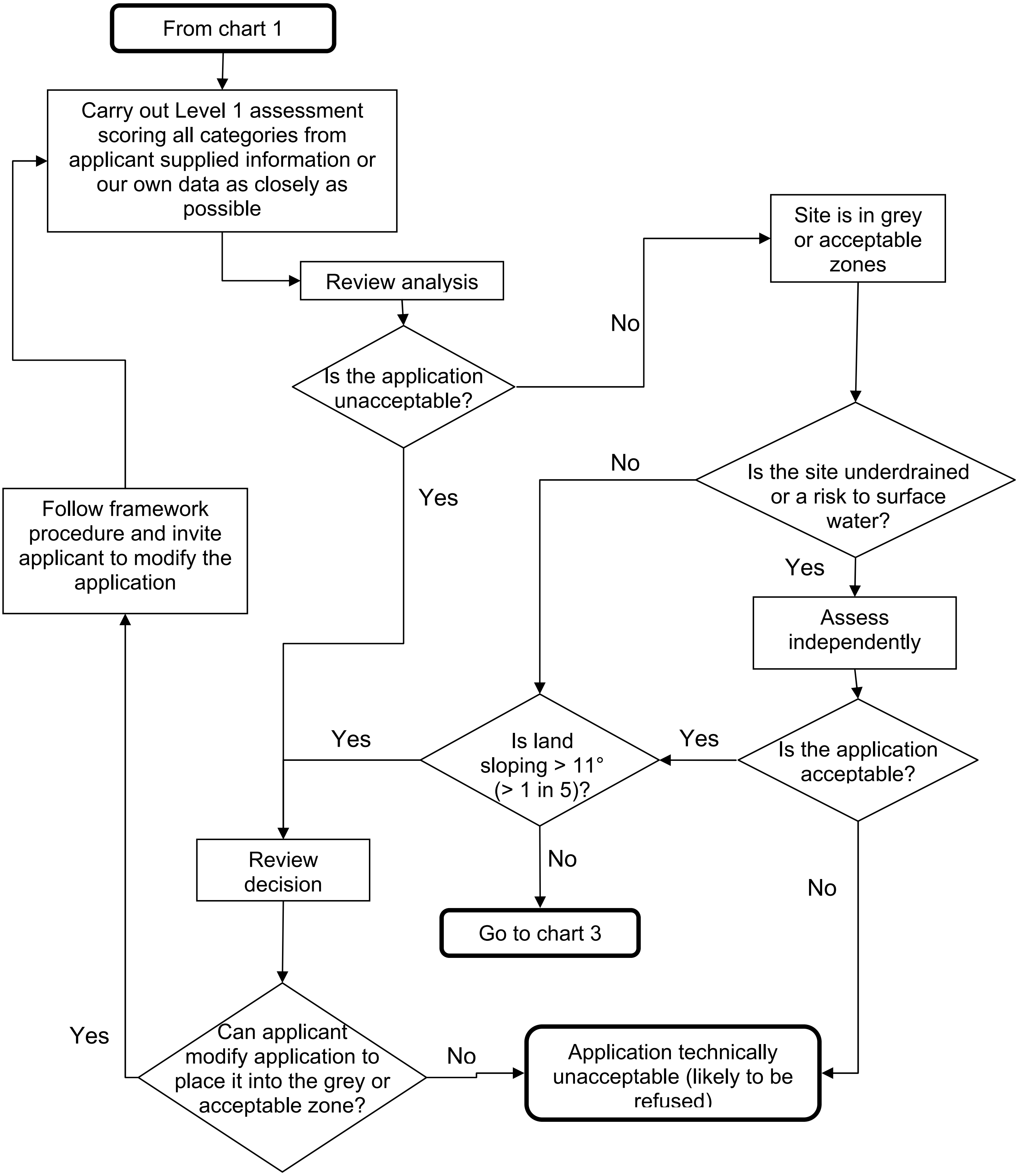
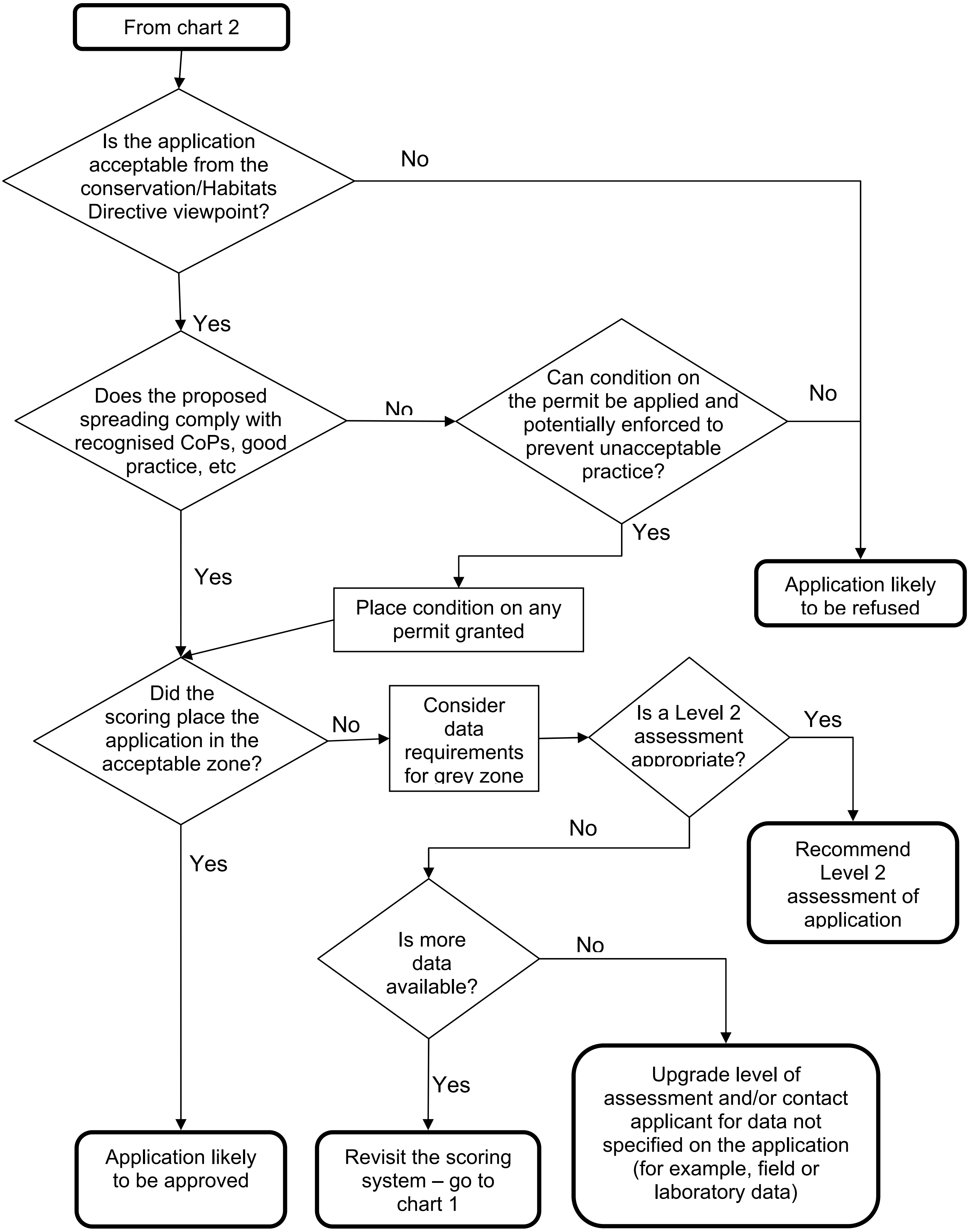


Chart 3 Continue here if application is acceptable or in 'grey zone' and the land required for discharge slopes less than 11° (from chart 2).



Note: More precise 'desk study' type data could refine scores significantly and change the status of the application.

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Determining sufficient evidence

Check for sufficient evidence

On receipt of the application form you must first determine whether there is sufficient information to enable the Level 1 assessment to be carried out. To determine this, quickly look through the returned application form and ensure that answers have been provided to the **key questions** identified in the Key questions table below.

Key questions

The table below lists the key questions that applicants should have provided answers for.

Question number	Why the response is required	Is the response provided? Y/N
*Part A (7)	Contact for further information	
*Part B (6a) (site map)	Inclusion on permit Aquifer scoring Proximity scoring	
*B7 (1a) (discharge area plans, one per discharge area)	Inclusion on permit Aquifer scoring Proximity scoring	
*B7 (1b) (one per discharge area)	Inclusion on permit Soil type scoring Aquifer scoring Proximity scoring	
*B7 (1d) (one per discharge area) *B7 app1 (5) & (8) (for sheep dip) *B7 app2 (6) & (9) (for pesticide washings)	Hydraulic load scoring	
B7 (2d)	Nature conservation assessment and consultation	
B7 (2e) (one per discharge area)	Soil type scoring	
B7 (2f) (one per discharge area)	Soil type scoring	

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B7 (2g) (one per discharge area)	Soil type scoring	
B7 (2h) (one per discharge area)	Soil type scoring	
B7 (2m) & (2n)	Land use scoring	
*B7 app1 (1) (for sheep dip) *B7 app2 (1) (for pesticide washings)	Inclusion on permit Substance mobility scoring	
B7 app1 (3) (one per substance) B7 app2 (4) (for pesticide washings)	Chemical loading scoring	
*B7 app1 (4) & (5) (one per substance) *B7 app2 (5) & (6) (for pesticide washings)	Chemical loading scoring	
*B7 app1 (6) (for sheep dip) *B7 app2 (7) (for pesticide washings)	Chemical loading scoring	

Essential and non-essential questions Responses to questions preceded with an asterisk (*) are essential. The assessment can not proceed without these. For those without asterisks, a response from the applicant is not absolutely essential, though you may be forced to make conservative assumptions that might result in the application being refused or upgraded to a higher level of assessment.

Essential questions not answered If 'N' is entered against any of the asterisked questions, contact the applicant to provide the missing data. You should normally delay any further technical assessment of the application until this information has been provided. However, if information is absent or unclear, conservative (but realistic) assumptions may initially be made, but note this may disadvantage the application as far as the scoring system is concerned.

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Determining the score for each factor

Calculate the score for each factor

The scoring assessment table (overpage) should be used to calculate and record the scores for each factor. The steps to be followed to determine the scores for each individual factor are:

Step	Action
1	Look up the question responses as indicated.
2	Refer to the indicated section for details of how to arrive at the risk for that factor.
3	Look up the score in the Matrix table (Appendix 1).
4	Add all the scores up and record that score in the TOTAL SCORE field.

The scores are used to determine the outcome of the application/reassessment following a review.

Note: Use one scoring assessment table per discharge area and substance.

Two Excel spreadsheets are available as supporting documents to assist with this process, and are available via the easinet. 105_05_SD01 relates to sheep dip discharges and 105_05_SD02 to pesticide washings discharges. If used, they should be printed and form part of the assessment record.

Record the score for each factor

Use the Scoring assessment table below to record your scores.

Scoring assessment table

Discharge area Code (for example A1)	**Substance Code (for example S1)**	**Combined Code (for example A1S1)**	
…A1…	…S1…	…A1S1…	
For…	**Check these responses…**	**Go to the following section…**	**Record the score here:**
Hydraulic loading	B7 (1d) C5 & C8 (for sheep dip) D6 & D9 (for pesticide washings)	Hydraulic loading scores	……
Chemical loading	B7 app1 (3 - 6) (for sheep dip) B7 app2 (4 – 7) (for pesticide washings)	Chemical loading score	……
Soil type	B7 (1b) B7 (2e – 2h)	Soil type score	……
Unsaturated zone thickness	B7 (2a – 2c) Our own records (i.e. liaise with local EM teams)	Unsaturated zone thickness score	……
Aquifer	B7 (1b) Site/discharge plan maps Our own maps	Aquifer score	……
Land use	B7 (2m and 2n)	Land use score	……
Substance mobility	B7 app1 (1) (for sheep dip) B7 app2 (1) (for pesticide washings)	Substance mobility score	……
Proximity to surface water	B7 (2a - 2c) B7 (1b) Site/discharge plan maps Our own maps	Proximity to receptor	……
Proximity to groundwater abstraction	Site/discharge plan maps Our own maps	Proximity to receptor	……
		TOTAL SCORE	……

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Using the matrix table

Look up the factor score

You should have deduced by now the risk associated with each Group 1 factor. Look up the score relevant to that risk in the Matrix table (Appendix 1.1) and record it in the scoring assessment table above.

Note: The upper rows for each factor in the matrix table are the assessment field limits. The lower rows (in bold) are the actual scores. Shaded boxes are where scores automatically place the discharge in the unacceptable category.

Determining the risks for each factor

Introduction

Purpose

This section explains in detail how to work out the level of risk (and hence a score) for each Group 1 factor.

Contents

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Hydraulic loading scores

Essential information from the response form

Given that the discharge method and equipment are the primary controls on the rate of spreading, adequate responses to questions B7 (1d), B7 app1 (5 to 9), or B7 app2 (6 to 10) on the application form, are essential to derive the score.

Note: there are different considerations that must be borne in mind with respect to waste / used sheep dip and pesticide washings discharges (see below).

Spreading rate guidelines

High rates of spreading can result in the field capacity of the soil being exceeded and the promotion of either:

1. rapid vertical infiltration by-pass flow;
2. overland flow, if the soil is of low permeability.

Due to the potential for these occurrences there is a spreading rate above which the activity cannot be adequately assessed using the Level 1 assessment.

For used / waste sheep dip

Working strength waste sheep dip should not be spread at rates greater than 5m^3/ha. If an operator has a reliable method of spreading at this rate, then the minimum area should be calculated and specified in a condition of the permit. (See Working out the score).

In many cases however, a vacuum tanker will be used to dispose of used dip, and, so the dip will require dilution with slurry or water in order to maintain the recommended 5m^3/ha spreading rate **of the dip** component since this equipment cannot achieve such a low rate. Most vacuum tankers have a rate of application fixed at approximately 20m^3/ha. This is 4 times the recommend rate for safe spreading. In order to ensure that the working strength dip is spread at the recommended 5m^3/ha rate, the dip must be diluted with at least three parts slurry or water. A check must also be performed using the responses to questions B7 (1d) and B7 app1 (5) to ensure that sufficient land is available to enable a single application. (see

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Working out the score).

For waste sheep dip, the maximum acceptable spreading rate has been set at 30 m^3/ha/day **after dilution**. However, good practice recommends a typical maximum rate of 20 m^3/ha (equivalent to an application rate of 2mm/d).

! Important Waste sheep dip must not be added to slurry stores prior to discharge (see Code of Practice for more details). In addition, agricultural effluents are controlled wastes; adding them to a slurry store would render the whole volume within the store a controlled waste. The inference, amongst others, being that this would require a very large discharge area required under a permit.

For pesticide washings

The "water code" allows spreading rates for slurries and the like, at up to 50 m^3/ha/day. Therefore, for pesticide washings **only**, higher spreading rates (that is, above 30 m^3/ha/day) are potentially acceptable, **but** are subject to more detailed, site specific assessment (see table below).

Calculation of hydraulic loading factor (pesticide washings)

Number of applications (examples)	**Application rate – single spreading**			
Working strength	>30 m^3/h/d	20 – 30 m^3/h/d Score band = 2	5.1 – 19 m^3/h/d Score band = 1	5 m^3/h/d or less Score band = 0.5
20	More detailed assessment	40	20	10
10	More detailed assessment	20	10	5
5	More detailed assessment	10	5	2.5
1	More detailed assessment	2	1	0.5

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Apply caution Given that in practice, the rate of spreading is governed by the equipment and method of discharge, rather than the total area of land available, care must be exercised that the value used in the Level 1 assessment is that which is achievable by the operator with available equipment. The scoring system encourages lower hydraulic loading as this is likely to reduce the risk of flow through the soil zone to the underlying groundwater.

Working out the score Work out the hydraulic loading score as follows:

Step	Action
1	Check and convert if necessary the relevant B7 (1d) (discharge area) response into hectares. Note: 1 hectare = 10,000 m^2 1 acre = 4047 m^2
2	Check responses to B7 app1 (9) (equipment application rate) (or B7 app2 (10) for pesticide washings). If required, ensure working strength sheep dip is diluted appropriately to ensure recommended $5m^3$/ha rate is maintained within any fixed application rate equipment used (e.g. if vacuum tanker has a rate of $20m^3$/ha, working strength volume must be diluted 3 to 1). Check this with response to B7 app1 (5) (or B7 app2 (6)) (after dilution).
3	Calculate min. spreading area as follows: Min. area (ha) = daily loading after dilution (m3/d) / application rate (m3/ha)
4	Multiply min. spreading area by response to B7 app1 (6) (or B7 app2 (7)) (no's discharges per year) and compare with response to B2d. Ensure there is sufficient discharge area available.
5	Apply a score for hydraulic loading using the Matrix table.

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Examples

Example 1(a) (using working strength sheep dip)

Assume 8m^3 of working strength dip requires discharge (B7 app1 (5)), three times a year (B7 app1 (6)), over a maximum discharge area of 5 ha (B7 (d)). The equipment spreading rate is 5m^3/ha (B7 app1 (9)).

Minimum spreading area (ha) = daily loading (m^3/d) / spreading rate (m^3/ha/)

Thus, the minimum spreading area (ha) = 8 / 5 = **1.6 ha**

Multiplying 1.6 by three discharges (B7 app1 (6)) calculates the total area required of **4.8 ha**.

[The score for this application rate is **0**, that is see the Matrix table in**]**

Example 1(b) (diluting working strength sheep dip for safe discharge)

Again, assume 8m^3 of working strength dip requires discharge (B7 app1 (5)), three times a year (B7 app1 (6)), over a maximum discharge area of 5 ha (B2d). A vacuum tanker with a minimum discharge/spreading rate of 20m^3/ha (B7 app1 (9)) is to be used.

The minimum **diluted** daily loading = volume of working strength dip (B7 app1 (5)) x 4 = 32m^3, that is to ensure a 3:1 dilution used.

Minimum spreading area (ha) = daily loading (m^3/d) / spreading rate (m^3/ha/)

Thus, the minimum spreading area (ha) = 32 / 20 = **1.6 ha**

Multiplying 1.6 by three discharges (B7 app1 (6)) calculates the total area required of **4.8 ha**.

Note The score for this application rate is **10**, that is see the Matrix table.

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Chemical loading scores

Follow good practice

The overall Level 1 assessment for chemical loading is based on current good practice. This has been derived from the normal concentration of active substance in typical sheep dip preparations (including recommended dilution to working strength) and good practice spreading rates.

! Important

The spreading of sheep dip preparations at greater strengths than the working strength for dipping recommended by the manufacturer is totally unacceptable.

Determining the score for used sheep dip

The information needed to assign a score is obtained from the type of chemicals used, and the estimated working strength.

Use the table below as a **guide** to determining the chemical loading score for different concentrations of waste **sheep dip** over individual discharge areas.

Note: This table shows example figures only.

Source material to be spread	Nominal concentration of active ingredients	Score assigned
Working strength	Up to 400 mg/l (OPs) Up to 250 mg/l (SPs)	6
Normal dilution for spreading (for example, 3:1)	10-150 mg/l (typical range)	4
Dilute washings and treated dip (which is subject to confirmation of effectiveness)	<10 mg/l	1

! Important Only one discharge of waste sheep dip per area of land per year is permitted.

Determining the score for pesticide washings

The information needed to assign a score is obtained from the type of chemicals used, and the estimated working strength.

For pesticide washings there is potentially a far wider range of substances and concentrations involved than for sheep dip concentrations and this is taken into account in the scoring system.

Use the table below to determine the chemical loading score for different concentrations of **pesticide washings** over individual discharge areas. It relies on the classification into hazardous substances and non-hazardous pollutants, the approximate strength of the material for discharge and the number of applications per annum over a specified area of land.

Note This table shows example figures only.

Source material to be spread	Nominal concentration of active ingredients	Score assigned	Number of applications per annum (examples)	Total score
High to moderate strength hazardous substances (e.g. working strength pesticides / herbicides)		6	6 (on one discharge area)	36
			6 on different discharge areas = 1	6
High to moderate strength non-hazardous pollutants only		3	6 (on one discharge area)	18
Very dilute hazardous substances (such as spray washings); low strength non-hazardous pollutants; very dilute mixtures or treated wastes (subject to confirmation of effectiveness)	Less than 2 mg/l of hazardous substance	1	10 (on one discharge area)	10

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What the scores relate to

A score is assigned that is related to the approximate concentration of active ingredient, multiplied by the number of applications per annum to give a total score that is related to the total annual load of the chemical **on each area of land**.

Note that in most cases, however, there will be more land available for spreading than that needed for an individual discharge. Therefore, discharges can be rotated between individual discharge areas to minimise the total annual loading on a single area and minimise the score. Conditions can be added to the groundwater activity permit to require rotation of discharges.

Hydraulic loading

For sheep dip and pesticide discharges, the scores for the hydraulic loading factor (which is assigned to the total volume regardless of strength) and the chemical loading factor have been balanced to reflect the overall risks of spreading differing dilutions and current good practice.

The assessment of chemical loading must take into consideration the hydraulic loading considerations outlined in Hydraulic loading scores and should be specific to a defined discharge area. The potential effect of treatment prior to discharge should be accounted for in the chemical load factor. To be able to take account of treatment, the concentration of active ingredients must be substantially reduced, for example, to a state equivalent to the dilute washings category. Only treatment methods that have been approved by us should be accounted for in the scoring system.

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Soil type scores

Determine the soil type

For the purposes of the Level 1 assessment, only the upper weathered and organic rich material near the surface is considered as soil.

Attenuation in the soil zone is a key element in the prevention of pollution by land spreading. Soil type, in principle, should be determined from the applicant's existing knowledge of soil conditions and desk study sources. Thus, to determine the soil type, use:

1. the information provided by the applicant on the characteristics of the soil;
2. your consideration of the soil classification system for the area as noted on the groundwater vulnerability maps; and
3. soil survey maps and NSRI soil information.

Interpret the responses

The table in Soil type categories highlights a procedure for translating the responses on the completed application to the three main classes under the 'soil type' factor:

1. High leaching potential;
2. Intermediate leaching potential;
3. Low leaching potential.

An additional (very high risk) category for very thin (<200mm) soils has been added to cover situations where there is little attenuating soil medium, either naturally or due to excavation. In situations where there is no natural soil and made ground is present, a site-specific assessment will be needed (the initial assumption should be that there is effectively no soil zone).

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Soil type categories The table below highlights the procedure for translating the soil type responses.

Soil (leaching) type	Question B7 (2e) response	Question B7 (2f) response	Question B7 (2g) response	Question B7 (2h) response	Assign overall risk category
Shallow depth	Shallow	N/A	N/A	N/A	Very high risk
High leaching	Moderate Deep	Stony Sandy Chalky Coarse-grained	Organic or not known	Free drainage	High risk
Intermediate leaching	Moderate Deep	Silty Loam Friable Medium-grained	Organic or not known	Moderate drainage	Medium risk
Low leaching	Moderate Deep	Clay Cohesive Plastic Fine-grained	Peaty	Poor draining	Low risk

Tick the boxes that apply to the soil you are considering and use the cumulative score (across rows) as a guide to allocating a leaching type.

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Ascertain the score

Ascertain the soil type score as follows:

Step	Action
1	Examine the answers provided to questions B7 (2e) through B7 (2g) from the application form for each identifiable discharge area.
2	Determine the soil type each identifiable discharge area using the applicant's responses and the table in Soil type categories as a guide. **Note** If the answer to question B7 (2e) is shallow, the soil type is immediately classified as 'Shallow' (very high risk), otherwise the soil is **initially** assigned to that soil type for which it has been assigned most responses. In the event of any ambiguity, the soil should initially be assigned to the higher risk (higher leaching potential) soil type, but it is recommended that clarification of the soil type is sought from the applicant. Assess this initial classification against that identified on the relevant Aquifer designation/Groundwater Vulnerability Map, Soil Survey map or soil data.
3	If the soil type deduced from the applicant's responses differs from that from published maps and/or our own information, contact the applicant and ask further questions to clarify the situation to confirm the soil type. Otherwise, go to the next step. Note: If the soil could still reasonably belong to one of two soil types, you should assign the soil to that type associated with higher (leaching) risk.
4	If there is no agreement between the applicant's information and other sources and the absence of reliable information would have a significant impact on the assessment, then consider using field data and a higher level of assessment. Otherwise, go to the next step.
5	Use the Matrix table in Look up the factor score to allocate the score.

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Other items to consider

The areal variability of soil types and thickness at the field scale should be considered wherever possible and separate assessments may be needed if the applicant's submitted discharge areas are extensive and/or cover different soil types.

Note Due to the perceived significance of the soil zone in attenuation, this factor and the chemical loading factor have a substantial effect on the final score. Field inspections of soil conditions should only be undertaken in cases of doubt where the soil conditions are the main factor in a potential refusal of an application.

Unsaturated zone thickness scores

When discharges are not allowed

Direct discharges of hazardous substances such as sheep dip and pesticides into groundwater, even in a diluted form, must be prevented under EPR 2010.

Obtaining evidence to estimate the depth to the water table

If accurate information on the depth to the water table is not initially available from the applicant, evidence may be obtained from a number sources.

For example, if the soils are waterlogged, this may be due to a high water table and some assumptions can be made based on the topographic location of the site, the location of springs, wetland plants, and the like. Similarly, a site on a valley side is unlikely to have a high water table but a site located in the base of a valley on alluvial deposits is likely to have a thin unsaturated zone.

We may also hold information on water table depth via hydrogeological maps or local information and the applicant may be able to supply information based on, for example, excavations made on site or the presence of a well / borehole, without the need for a site-specific investigation.

Even if only a rough estimate can be made, this should be undertaken and the lowest **reasonable** thickness of unsaturated zone used in the Level 1 assessment.

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Classify and score

In the absence of any supporting evidence, the 'Very high' risk case should be taken if there is a possibility of a very thin (<0.5 m) unsaturated zone during the period of spreading. The need for further investigation can then be assessed based on the impact of this factor on the total score assigned.

Where there is a substantial thickness (≥5 m over the discharge area) of low permeability Non-Productive Strata (either drift or a solid formation), the unsaturated zone should be assumed to be over 15 m thick.

In estimating the depth of the unsaturated zone, account should be taken of any suspected seasonal variation in water levels. This is particularly important in aquifers such as chalk and Carboniferous limestone.

Consultation with local Environment Management teams is very important in terms of clarifying the depth of the unsaturated zone. When the risk factor has been determined, use the Matrix table in Look up the factor score to allocate the score.

Aquifer scores

Determine the aquifer type

The aquifer type can be determined from:

- the name of the strata/sequence indicated by the applicant and/or from available geological maps;
- consultation with the relevant Aquifer designation/Groundwater Vulnerability Map for the discharge site.

Note: Care should be taken over some previously designated 'Non-Aquifers' as some of these formations may locally support significant groundwater abstractions. Some Non-Aquifers are now designated as 'Secondary Aquifers'.

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Take Karst into account

Karst is included to cover situations where there are major solution features and the risk of swallow holes and pipe/conduit flow. This should only be applied where Karst development is known or strongly suspected in the vicinity of the site and not necessarily to the entire aquifer. A standard condition may be applied to reduce the risk from discharge around known solution features. Normally the 'high permeability' score should be applied where the unsaturated zone is known to be fissured since fissure-flow could be the dominant flow mechanism.

Exclude drift cover

Drift cover has been deliberately excluded from the main part of the scoring system because in most cases it is difficult to ascertain at the desk study stage. However, if it is well known that there is a substantial layer (>5 m over the entire spreading site) of low permeability material beneath the site then this in effect should be regarded as the receptor and scored as low risk accordingly. In addition, in situations where there is a considerable thickness of relatively impermeable solid strata, a score of -15 can be applied to the total score for the application; this would not normally be applied to drift because of the heterogeneity of such strata.

Note the presence of impermeable layers beneath the spreading area may result an increased potential risk of surface water pollution, which should form part of the overall technical assessment.

Classify and score

When the risk factor has been determined, use the Matrix table in Look up the factor score to allocate the score.

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Land use scores

Condition of the land

Three basic classifications are used in the Level 1 assessment:

- bare;
- vegetated soil;
- permanent pasture.

The land use should relate to the conditions at the time of the proposed discharge. Permanent pasture can include temporarily fallow land, providing it is not to be disturbed for many months (ideally 12) after the discharge.

Classify and score

When the land use classification has been determined, use the Matrix table in Look up the factor score to allocate the score.

Substance mobility scores

Qualitative measure used

For substance mobility, a simple qualitative measurement is used based on the relative mobility of the main hazardous substances chemicals in water. Potential effect of treatment is covered in the chemical load factor.

Grade used for sheep dip

Synthetic pyrethroid (SP) compounds are considered high risk; organophosphorus (OP) medium risk, and bloom dip low risk.

Grade used for pesticide washings

The grading shown in the table below is based primarily on the solubility of the substance and the perceived propensity to leaching through the soil zone.

Where mixtures containing several polluting substances are involved, the assessment should be undertaken on the basis of using the most mobile significant component, taking into consideration substances present at concentrations above drinking water standards and hazardous substances.

In the absence of a grading, a high mobility should be assumed.

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Substances	**High mobility**	**Moderate mobility**	**Low mobility**
Pesticides	Aldicarb	Lindane	Most organochlorines: Diazinon Most organophosphates: Chlorfenvinphos Dichlorvos Dimethoate Synthetic pyrethroids: Permethrin Cypermethrin
Herbicides	Chlorotoluron Mecoprop Bentazone Triazines: Atrazine Simazine.	Isoproturon Diuron Carbendzim	MCPA
Metals	Selenium	Aluminium Arsenic Chromium Lead Nickel Zinc	Copper Mercury Cadmium
Biocides	---	Formaldehyde	---
Others	Nitrate Fluorides Chloride (high concentrations)	Ammonium Phosphates	**---**

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Score	When substance mobility risks for both used sheep dip and pesticide washings have been determined, use the Matrix table in Look up the factor score to allocate the scores.

Proximity to receptor scores

What to consider

There are two subdivisions:

- proximity to surface watercourses and groundwater fed springs;
- proximity to groundwater abstractions from wells and boreholes.

The main requirement is to be consistent with existing codes of good practice, which indicate that there should be no spreading within 10 m of a watercourse or 50 m of a groundwater abstraction. This is reinforced by standard conditions. You should also have regard to the revised Groundwater protection: policy and practice (GP3).

Springs

Springs should be scored as groundwater abstractions if the discharge is up-gradient of the spring and be scored as surface water if the discharge is down-gradient. This recognizes the gravity-driven nature of these surface expressions of groundwater flow.

Groundwater proximity and aquifer abstractions

The link between the groundwater proximity and aquifer abstractions should be noted. This link and the need to protect groundwater regardless of the presence of abstractions is the reason for the apparent low scoring on proximity alone.

Classify and score

When the risk has been determined, use the Matrix table in Look up the factor score to allocate the score.

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Considering topography

Where and how is this used

This is used in the process flowcharts rather than the scoring system but nonetheless is a material consideration in terms of compliance with the relevant codes of practice. Topography may to be assessed directly from Ordnance Survey maps and/or by site assessment. Discharge on steep land should be removed from the permitted discharge area by condition.

Interpreting the scores

Uncertain scores

Once the relevant information has been taken from the application form and / or our own data, it may be apparent that there is a high degree of uncertainty attached to some of the scores.

Initially, a precautionary view should be taken and the highest **reasonable** score allocated for the factor in doubt.

If the proposed discharge is…	then…
in the acceptable range	the application can proceed.
in the grey zone and prior to undertaking a formal Level 2 assessment	a sensitivity/uncertainty assessment should be undertaken on the main determining factors, and in particular those where there is major uncertainty or where assumptions have had to be made.

Resolving uncertainty

The potential effect of resolving uncertainty and the measures needed to resolve it should then be reviewed.

You may be able to resolve uncertainty by a phone call to the applicant, reference to readily accessible (published) information or reference to the local knowledge of field officers. The aim should be to spend a minimum of time reviewing the uncertainty but it is equally important to ensure that only those applications that **genuinely** require a higher level of technical assessment are carried forward to a formal Level 2 assessment.

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Large quantity of information required

Where it is apparent that a great deal of information is required from the applicant to demonstrate that the proposed discharge can be permitted (this would normally involve the collection of field data), then a higher level of assessment is likely to be appropriate.

Scores in the grey zone

Whilst a Level 1 screening score of 50–79 is technically within the grey zone, this **does not** necessarily mean that a Level 2 assessment is automatically required. Further consideration is required (essentially by the groundwater and contaminated land teams) but may, on a site-specific basis, conclude that a Level 2 assessment is not necessary.

If for example, some potential discharges fell just within the grey zone (that is, 51–56) the reason **may** be due to a conservative assumption made, amongst others, in relation to a sole factor, say the depth of the unsaturated zone. In this example, an assumption of shallow depth would result in a high score factor for the depth to the unsaturated zone. If, following consultation, the groundwater and contaminated land teams considered the assumption inappropriate, then consideration of this opinion would result in:

- a reduction of the score factor for the unsaturated zone;
- a corresponding reduction in the overall Level 1 screening score.

Conceivably, the overall screening score could fall below 50 thereby removing the need to carry out a full Level 2 assessment.

Taking non-groundwater elements into account

Within the Level 1 screening matrix, it is important to note that not all elements of the matrix relate directly to groundwater. For example proximity to nearest surface water will, depending on distance, result in a score of between 80 (<10 m) to 0 (>50 m). Thus, if the Level 1 screening matrix falls within the 51 + range and the high score is due predominantly to non-groundwater elements, then there is little merit in carrying out a formal Level 2 assessment. Alternative actions, such as moving the discharge area, should be considered to enable the score matrix to be reduced.

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Use of multiple areas for discharge

Purpose

This section advises on:

- how to decide how many discharge (disposal) areas are acceptable under a single groundwater activity permit;
- whether one application and subsistence fee is appropriate.

Deciding the need for separate applications

The application form allows an operator to apply for more than one type of substance and/or more than one discharge area in a single submission. This is for simplicity in completing the forms. Depending on the information contained in the application you may decide that separate applications must be made for each substance and/or discharge area. Use the following information to make this decision.

When to seek multiple disposal areas

Multiple discharge areas may be sought for three reasons:

1. The nature of the land means that a single, large site cannot be found.
2. Different waste streams must be discharged separately.
3. The operator wishes to rotate the discharge area periodically.

Number of waste streams

The number of applications and/or permits required for multiple waste streams is determined by the number of prior examinations required to assess the discharge areas.

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Number of disposal areas

Where an application is received for more than one discharge area, consider whether there is a significant amount of additional work required for assessing the risk of additional discharge areas within one application.

For multiple discharge areas it may still be possible for you to assess these using a single prior examination. As a guide, if you decide that a single prior examination will not be sufficient to assess the application for multiple discharge areas, then treat these as separate applications requiring separate fees.

If the ground conditions are not dissimilar, or the discharge areas are adjacent to each other, and satisfactory monitoring arrangements can be made, it may be acceptable to include multiple discharge areas in the same groundwater activity permit. If you are to accept a single application the applicant must provide you with sufficient information to assess this. You may require additional information from them to avoid unnecessary workload for us, and avoid an additional application charge.

Rotation of disposal areas

In some cases discharge areas may be periodically rotated depending, for example, on cropping or other needs. Where there are no or minimal adverse impacts of rotating and it is found to be beneficial, rotating discharge areas must not be discouraged by unnecessary restrictions on the number of discharge areas.

In areas where groundwater is vulnerable or where there are concerns about risks to conservation interests, you must carefully consider the acceptability of rotation and therefore whether multiple discharge areas can be included in the same application.

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Volumes and concentration

Discharges of small volumes of dilute substances normally present less of a pollution risk, therefore they may require less effort to assess, permit and subsequently monitor and enforce. It may be appropriate to allow multiple discharge areas for this type of discharge (for example, dilute pesticide washings).

You may feel it appropriate to restrict the number of discharge areas for more concentrated substances (such as untreated used sheep dip). This may also help to balance the income received with the work required to assess, permit and monitor such applications.

Monitoring and review of permits

The work needed to ‘service’ a groundwater permit is also a relevant consideration when deciding whether to accept multiple discharge areas on a single application.

If you believe that multiple discharge can be monitored and reviewed periodically using similar effort to that required for a single discharge area, you may accept multiple discharge areas on a single application.

In order to determine whether a similar or greater effort will be required, consider the following issues:

1. Can the discharge be considered as a single effluent or waste stream?
2. Will any requisite surveillance carried out in relation to one discharge area be sufficient for other areas?
3. Can site visits to one area cover other areas without extending the time required unreasonably (more than one hour)?
4. Can the periodic review of one area be extended to cover other areas without increasing the assessment time unreasonably?

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If more than one application required

If you decide that more than one application/ permit is required, you must notify the applicant as soon as possible.

In some cases the applicant may wish to reconsider whether all of the discharge areas are required. If the applicant decides to reduce the number of discharge areas, the areas which pose the least environmental risk must be identified.

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Appendix 1.1

Matrix table	**Very high or unacceptable risk**	**High risk**	**Medium risk**	**Low risk**
Hydraulic loading rate (sheep dip)	>30 m3/ha/d	21-30 m3/ha/d	5.1-20 m3/ha/d	≤5 m3/ha/d
	80	15	10	0
Hydraulic loading rate (pesticide washings)	>30 m3/ha/d	20-30 m3/ha/d	5.1-19 m3/ha/d	≤5 m3/ha/d
	Assess in more detail	2 (note 1)	1 (note 1)	0.5 (note 1)
Chemical loading	Use the tables in Chemical loading scores	Use the tables in Chemical loading scores	Use the tables in Chemical loading scores	Use the tables in Chemical loading scores
Soil type	Shallow (<200 mm)	High leaching	Intermediate leaching	Low leaching
	25	15	5	0
Unsaturated zone	<0.5 m	0.5-4.9 m	5-15 m	>15 m or non-aquifer cover (note 2)
	80	15	10	0
Aquifer	Karst	Principal Aquifer (high permeability)	Secondary Aquifer (variable permeability)	Unproductive strata (low permeability) or non-aquifer cover (note 2 & 3)
	25	15	5	0
Land use	----	Bare soil	Vegetated soil	Permanent pasture
		15	5	0
Substance mobility (sheep dip)	----	SP	OP	Bloom Dip
		15	10	5

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Substance mobility (pesticide washings)	----	High mobility	Moderate mobility	Low mobility
		15	10	0
Proximity to surface water	<10 m	10-29 m	30-49 m	50 m
	80	15	5	0
Proximity to groundwater abstractions	<50 m	50-250 m or Zone I	250-500 m or Zone II	500 m
	80	15	5	0

Note 1: Score band for pesticide washings needs to be multiplied by the number of applications if on a single area of land

Note 2: At least 5m of undisturbed relatively impermeable cover known to exist over the entire spreading area. If a site-specific investigation is needed to confirm presence, the next level of assessment may be appropriate.

Note 3: Where there is a considerable thickness of relatively impermeable non-aquifer (for example, 10m of the Oxford, London or Kimmeridge Clay), add a score of -15 to the total score for the application.

Technical Annex to Annex (j) – Glossary of terms

Glossary of terms

Aquifer	A subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater (Water Framework Directive, 2000).
Attenuation	A decrease in contaminant concentration or flux through biological, chemical and physical processes, individually or in combination (e.g. dispersion, precipitation, ion exchange, biodegradation, oxidation, reduction). See also *“natural attenuation”.*
Background	See *“baseline”*
Baseline	In the context of an environmental permit, the measurements that characterise the pre-permit physical, chemical or other distinctive properties of groundwater and surface water beneath / around a site.
Biodegradation	The breakdown of a substance or chemical by biological organisms, usually bacteria.
Compliance point	A compliance point is a suitable point along the contaminant pathway between the source and a receptor at which you set a compliance value. The compliance point may be a virtual point (for the purpose of predictive assessments) or it may be a physical monitoring point such as a borehole. In some cases the compliance point may be the receptor itself.
Compliance value	This is a concentration at the compliance point that should not be exceeded. Depending on the level of assessment, a compliance value may take account of some or all of the dilution and attenuation processes along the contaminant pathway to the receptor(s).
Conceptual model	A simplified representation or working description of how the real (hydrogeological) system is believed to behave based on qualitative analysis of field data. A quantitative conceptual model includes preliminary calculations for the key processes.

Technical Annex to Annex (j) – Glossary of terms

Conservative contaminants	*Contaminants* which can move readily through a permeable medium with little or no reaction and which are unaffected by biodegradation (e.g. chloride).
Contamination / contaminant	The introduction of any substance to water at a concentration exceeding the *baseline* concentration. A contaminant is any such substance.
Detection limit	The lowest concentration of a substance that can be reliably measured to be different from zero concentration.
Dilution	Reduction in concentration brought about by mixing (typically with water).
Dilution factor	The dilution factor describes the amount of dilution of the discharge by groundwater flow and is calculated from the ratio of groundwater below the discharge area and the discharge.
Discharge	Spreading of waste sheep dip or pesticide washing to the ground surface
Dispersion	Groundwater - Irregular spreading of solutes due to heterogeneities in groundwater systems at pore-grain scale (microscopic dispersion) or at field scale (macroscopic dispersion).
Down-gradient	In the direction of decreasing water level (i.e. in groundwater this is following the *hydraulic gradient*).
Environmental quality standard (EQS)	A water quality and biological standard for a surface watercourse.
Groundwater	In this document the definition used is that given in the Water Framework Directive (2000/60/EC) as “all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil”.
Hazardous substances	Defined in the WFD as: “substances or groups of substances that are toxic, persistent and liable to bio-accumulate, and other substances or groups of substances which give rise to an equivalent level of concern.”
Hydrophyllic	Molecule which dissolves readily in water

Technical Annex to Annex (j) – Glossary of terms

Hydraulic conductivity	A coefficient of proportionality describing the rate at which a fluid can move through a medium. The density and kinematic viscosity of the fluid affect the hydraulic conductivity, so that this parameter is dependent on the fluid as well as the medium. Hydraulic conductivity is an expression of the rate of flow of a given fluid through unit area and thickness of the medium, under unit differential pressure at a given temperature. (*See also "permeability")*.
Hydraulic gradient	The change in total *head* (of water) with distance in a given direction. The direction is that which yields a maximum rate of decrease in head.
Minimum reporting value (MRV)	The lowest concentration of a substance which is reported in the results of an analysis. It is not necessarily the *detection limit*.
Natural attenuation	Natural processes which, without human intervention, reduce the concentration, mass, flux or toxicity of *contaminants* in groundwater and surface water.
Non-hazardous pollutant	Any substance capable of causing pollution that has not been classified as a hazardous substance. The Non-Hazardous list of substances does not simply replace the old List II Substances, as for example, nitrate is now termed as being Non-Hazardous whereas before it was not a listed substance.
Pathway	The route alone which a particle of water, substance or contaminant moves through the environment e.g. the route contaminants are transported between the source of landfill leachate and a water *receptor*.
Permeability	A measure of the rate at which a fluid will move through a medium. The permeability of a medium is independent of the properties of the fluid. See also "*hydraulic conductivity*".
Pollutant	Water Framework Directive: "any substance liable to cause *pollution*, in particular those listed in Annex VIII [of the WFD]".

Technical Annex to Annex (j) – Glossary of terms

Pollution	Defined in EPR (2010) as: "the direct or indirect introduction, as a result of human activity, of substances or heat into the air, water or land which may be harmful to human health or the quality of aquatic ecosystems or terrestrial ecosystems directly depending on aquatic ecosystems, which result in damage to material property, or which impair or interfere with amenities or other legitimate uses of the environment."
Porosity	The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment.
Potable water	Water of suitable quality for drinking
Principal aquifer	Geological strata that exhibit high permeability and usually provide a high level of water storage. They are capable of supporting water supply on a strategic scale and are often of major importance to river base flow (formerly known as major aquifer).
Receptor	An entity/organism or a controlled water that is being or could be harmed by a potential pollutant, such as groundwater or surface water resource, amenity or abstraction point.
Recharge	The amount of water added to the groundwater system by natural or artificial processes.
Retardation	A measure of the reduction in solute velocity relative to the velocity of the flowing groundwater caused by processes such as adsorption.
Risk	A quantitative or qualitative combination of the probability of a defined *hazard* causing an adverse consequence at a *receptor*, and the magnitude of that consequence.
Risk assessment	The process of identifying and quantifying a risk, and assessing the significance of that risk in relation to other risks.
Saturated zone	The zone in which the voids of the rock or soil are filled with water at a pressure greater than atmospheric. The water table is the top of the saturated zone in an unconfined groundwater system. In general, flow on a macro scale is horizontal and typically faster than for unsaturated zone flow. Flow rates between different types of strata vary over several orders of magnitude.
Sorption	Absorption and adsorption considered jointly

Technical Annex to Annex (j) – Glossary of terms

Unproductive strata	These are geological strata with low permeability that have negligible significance for water supply or river base flow (formerly part of the non-aquifers).
Unsaturated zone	The zone between the land surface and the water table. The pore space contains water at less than atmospheric pressure, as well as air and other gases. Saturated bodies, such as perched groundwater may exist in the unsaturated zone. Also called the vadose zone.
Up-gradient	In the direction of increasing *hydraulic head* (i.e. in groundwater this is moving up the *hydraulic gradient*).

Technical Annex to Annex (j) – List of abbreviations

List of abbreviations

AF	Attenuation Factor
BGS	British Geological Survey
BS	British Standard
DF	Dilution Factor
EPR	Environmental Permitting Regulations
GP3	Groundwater Protection: Policy and Practice
MRV	Minimum Reporting Value
OP	Organophosphorus
SP	Synthetic pyrethroid
SPZ	Source Protection Zone
WFD	Water Framework Directive

Technical Annex to Annex (j) – References

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