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Habitats regulations for Stage 3 assessments: radioactive substances authorisations

R&D Technical Report P3-101/SP1a

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The report is aimed at assisting the development of functional guidance for Environment Agency staff, tasked with assessing the impact of ionising radiation to wildlife for the purpose of Stage 3 Assessment.
The report also describes and explains the methodology that was followed and therefore could be applied to other assessment purposes.

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Executive summary

The UK has a duty to comply with the EU Birds and Habitats Directives when planning and undertaking all of its regulatory and operational activities. These European Directives were introduced into UK legislation by the Conservation (Natural Habitats) Regulations 1994, as amended by the Conservation (Natural Habitats) (England) Regulations 2000.

Under these Regulations, the Environment Agency has obligations to review all existing authorisations, permits, consents, licences and permissions to ensure that no Agency authorised activity or permission results in an adverse effect, either directly or indirectly, on the integrity of identified European sites. In this context, European sites consist of classified or potential Special Protection Areas (SPA) created under the Wild Birds Directive and candidate or designated Special Areas of Conservation (SAC) under the Habitats Directive. These sites are collectively referred to as Natura 2000 sites.

In relation to radioactive substances authorisations, the Environment Agency has completed Stage 1 Assessments of the Natura 2000 sites in England and Wales by virtue of the dischargesí locations, as well as Stage 2 Assessments through the calculations of screening discharge levels that may have an effect on the features of interest at a given European site. As a result of these assessments, approximately 100 permissions have been identified that may have a potential impact on Natura 2000 sites and thus require further detailed assessment (Stage 3). The Stage 3 Assessments are to take place over the next five years, starting in 2003.

This Environment Agency R&D project was commissioned to ERC, University of Liverpool, in conjunction with Westlakes Scientific Consulting and the Centre for Ecology and Hydrology, as part of the Agencyís preparation for the Stage 3 Assessments of radioactive substances authorisations. The aim was to prepare site information sheets containing all data relevant for individual Natura 2000 sites needing Stage 3 Assessment and to stylise and represent species that require protection under the Habitats Regulations by the reference organism geometries listed in R&D Publication 128 (Copplestone et al., 2001).

The objectives of this project were as follows:

- to compile a list of species requiring protection under the Habitats Regulations at each Natura 2000 site potentially impacted by discharges of radioactive substances;
- to collate information on the biology and ecology of each identified species in order to represent them using the most appropriate reference organism geometries in the dose assessment spreadsheets from R&D Publication 128;
- to identify concentration factors (CFs) for each radionuclide listed in the authorisations that may have a potential impact on the Natura 2000 sites;
- to provide guidance on how to use the collated information in the dose assessment spreadsheets, provided in R&D Publication 128, for the Stage 3 Assessments.

These objectives have been achieved through a review of Environment Agency data (Habitats Database) and scientific literature for biological and ecological characteristics of the species identified under the Functional Guidance (EA, 2002). An assessment of the geometric shapes (assumed to be ellipsoidal) of the feature species in comparison with the reference organism geometries already listed in R&D Publication 128 was conducted. The most suitable geometric shapes (for the purposes of dosimetry) have been identified for species to be assessed in each of the three ecosystem dose assessment spreadsheets (coastal, freshwater and terrestrial). Attempts to determine relevant and appropriate CFs for the radionuclides requiring assessment have been made with mixed results. Alternative methods of identifying realistic but conservative values for the CFs have been employed, and all of the information has been compiled into a series of site information sheets. These sheets provide an assessor with the input data required for the dose assessment spreadsheets in order to conduct a Stage 3 Assessment. Guidance on the approach to adopt has been provided, along with supporting information to justify the recommended approach. The flow chart below details the steps to be taken in the assessment.

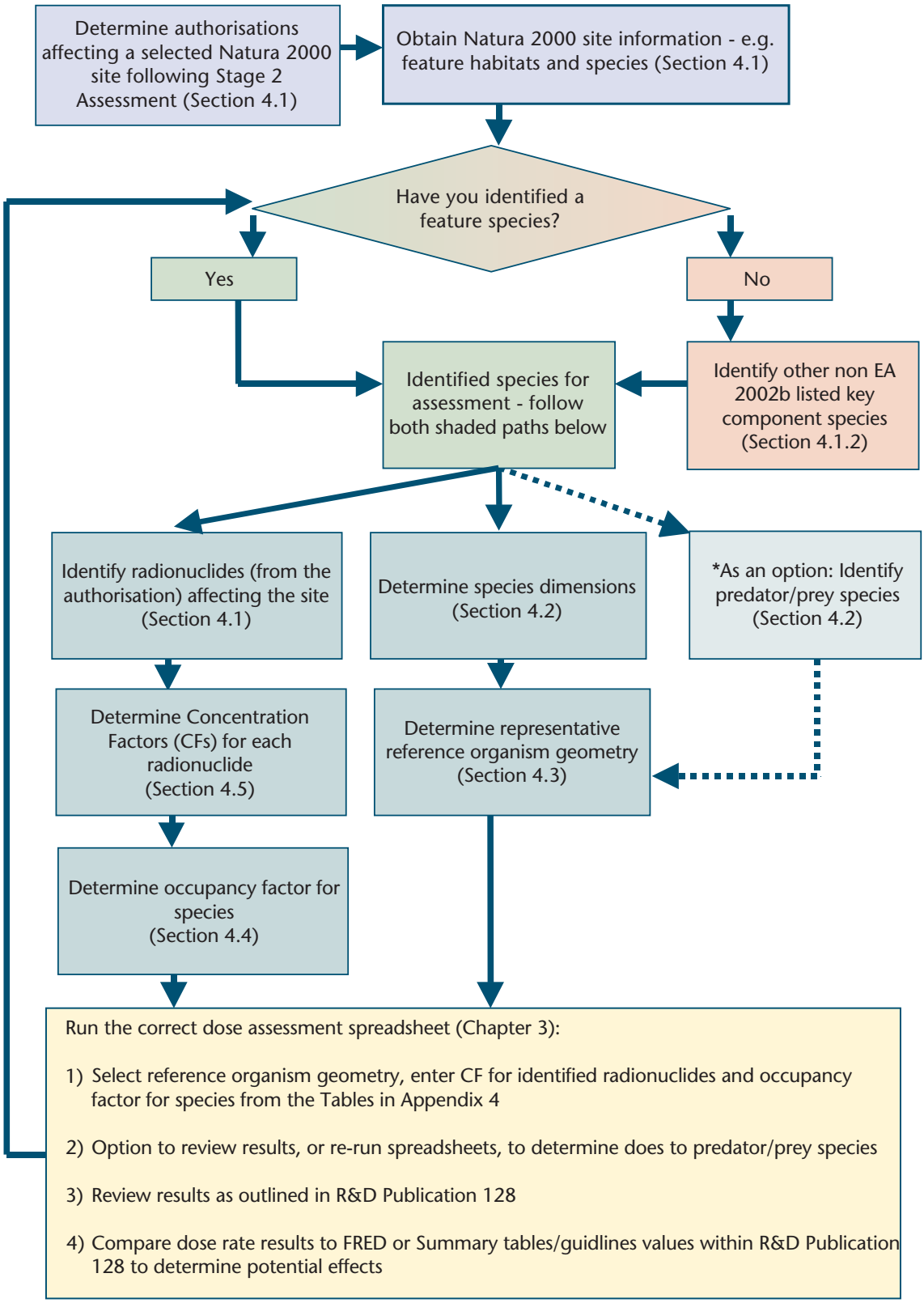
The information in Appendix 4 has been categorised by Environment Agency regions and areas, and then alphabetically by Natura 2000 site. It contains all the information necessary for an assessor to carry out a Stage 3 Assessment of the radioactive substances authorisations for all the permissions identified to the project team by the Environment Agency. The flow chart below summarises the process of how to determine the necessary information for any additional permissions that have not been identified to date.

It should be noted that the recommended assessment approach relies on the identification of key species that require protection. The recommended approach can provide dose rate estimates tor the identified key species.

It should also be noted that the Habitats Regulations identify habitat features (such as estuaries) that should be protected. The assessment approach recommended in this report does not provide a mechanism by which it can be shown that habitat features per se are protected from the impact of ionising radiation. However, the recommended approach does identify key component species of these habitats (not listed under the Habitats Regulations) which could be assessed in the manner outlined in this report. In this way, it may be possible to demonstrate adequately that the key component species of the habitat feature are sufficiently protected ó and thus, by inference, that the habitat feature is also protected. However, further discussions with relevant conservation bodies on how best to demonstrate adequate protection of habitat features is recommended.

The assessment approach outlined in this report should provide a robust approach for determining the potential impact of ionising radiation on wildlife. However, it is recognised that there may be uncertainty of the derivation of the values used in this report. At appropriate points, the reasons for the uncertainties and any assumptions that are used are clearly outlined. These may arise from points specific to this report or to the assumptions outlined in R&D Publication 128. For example, the derivation of the CFs may, with some validity, be questioned. The approach adopted has attempted to be conservative in the derivation of CFs, and hence the assessment itself should be conservative. If in doubt, a more rigorous site-specific assessment should be repeated using CFs derived from site-specific data. The importance of site-specific data cannot be underestimated in order to prove conclusively that wildlife species inhabiting a particular site are adequately protected from exposure to ionising radiation.

Flow chart of the assessment process



* Note. Assessments in this report are restricted only to species listed under EA Handbook (2002). However other species information has been identified and incorporated in Appendix 3 Tables

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Held on CD at back of report

- **Appendix 4: Natura 2000 site information for assessors, catalogued for each Environment Agency Region**
- **Appendix 5: Supporting data for the selection of appropriate reference organism geometries for the feature species**

List of Tables and Figures

Acknowledgements

The project manager wishes to thank all Environment Agency staff who helped in providing information for each Natura 2000 site/EA authorisation. Special thanks to Peter Merrill, who has taken the lead in overseeing the quality of the collated information. Peter also made sure that the R&D project would deliver a product that could be translated into better Environment Agency guidance for implementing Habitats Regulations for Stage 3 Assessment of radioactive substances authorisations.

Particular thanks also go to Jill Sutcliffe from English Nature, who has taken an active part in the project as a member of the steering group. Jill has provided valuable contributions by raising conservation issues and concerns to be taken on board within this project.

1. Background

The UK has a duty to comply with the EU Birds and Habitats Directives (Council Directives 79/409/EEC on the conservation of wild birds and 92/43/EEC on the conservation of natural habitats and wild flora and fauna) when planning and undertaking all of its regulatory and operational activities. These European Directives were introduced into UK legislation by the Conservation (Natural Habitats) Regulations 1994, as amended by the Conservation (Natural Habitats) (England) Regulations 2000.

Under these Regulations, the Environment Agency has obligations to review relevant existing, authorisations, permits, consents, licences and permissions (hereafter collectively referred to as permissions) to ensure that no Agency-authorised activity or permission results in an adverse effect, either directly or indirectly, on the integrity of identified European sites. In this context, European sites consist of classified or potential Special Protection Areas (SPA) created under the Wild Birds Directive and candidate or designated Special Areas of Conservation (SAC) under the Habitats Directive. These are collectively referred to as Natura 2000 sites.

This report provides guidance and supporting information to enable the Environment Agency to undertake a Stage 3 Assessment of all Natura 2000 sites that may potentially be impacted by the Radioactive Substance Authorisations (RSAs), as identified following Stage 1 and 2 Assessments. Stage 1 and 2 Assessments have determined the number of potentially impacted sites following the approach described in the Environment Agency document *Functional Guidance on applying the Habitats Regulations to Radioactive Substance Authorisations EA Habitats Handbook* (2002).

The review process, which was not part of this project, has taken the form of an initial screening to filter out applications and activities which, by virtue of their nature or location, could not conceivably have an effect on the interest features of given European sites (Stage 1). Stage 2 Assessment then reviewed the maximum permissible radioactive discharge levels from authorised sites and compared these to defined screening levels (Allott and Dunn, 2001). As a result of Stage 2, approximately 100 authorisations have been identified that may have a potential impact on Natura 2000 sites and thus require further assessment (Stage 3). Stage 3 Assessments are to be conducted over the next five years starting in 2003, using the methodology described in R&D Publication 128 (Copplestone *et al.*, 2001).

2. Objectives

Stage 3 Assessments will determine the significance of any effect resulting from a single permission or combination of permissions on the Natura 2000 site(s). The Stage 3 process must make an appropriate assessment for each European site in view of the site's conservation objectives, and determine whether to affirm, modify or revoke the permission.

Staff must determine the potential impact of each authorisation on specific species that have been identified as requiring protection under the conservation legislation (Birds and Habitats Directives). This requires all the listed species to be stylised and represented by the reference organisms described in R&D Publication 128 and any data gaps identified that relate to the assessment methodology being adopted. In addition to protecting feature species, feature habitats may also require protection. Feature habitats may be defined because of geological characteristics, or for biodiversity reasons, rather than the protection of specific feature species.

Guidance on how to deal with this is provided in Section 4.1.2.

This project aims to ensure that aspects of Natura 2000 sites that require protection under the Birds and Habitats Directives are adequately protected from discharges of radiaoactive substances by:

- compiling a list of species from EA (2002) that require protection in association with the sites affected by radioactive substance authorisations;
- collating information on the biology and ecology of the identified species (geometry, feeding habits, predators, and habitat occupancy);
- identifying which reference geometries incorporated in the dose assessment spreadsheets would best represent those biota;
- identifying, from Environment Agency information, which radionuclides present in the authorisations have the potential to impact on their associated Natura 2000 sites;
- identifying concentration factors (CFs) for each species for each radionuclide of interest;
- compiling a list of habitats from EA (2002) that require protection in association with the sites affected by radioactive substance authorisations;
- summarising the habitat features list in terms of species that require protection;
- providing guidance on how to combine all the collated information in order to use the dose assessment spreadsheets provided in R&D Publication 128 for Stage 3 Assessments;
- providing summary tables for each Natura 2000 site containing all the necessary information for the assessors;
- deriving research needs where literature data are found to be insufficient to support adequate representation and/or assessment.

The report is divided into the following parts, which together address all of the above objectives.

- Production of guidance for assessors (Chapter 3). This summarises the information that underlies the methodology (Chapter 4) needed to produce all the summary tables in Appendix 4.
- Identification and collection of data on the Natura 2000 sites affected by the RSA authorisations (Section 4.1).
- Review of species characteristics (Section 4.2).
- Determination of the appropriate justifiable representation of these species by the reference organism geometries used in R&D Publication 128 (Section 4.3).
- Evaluation of the literature to identify appropriate concentration factors for use in the Stage 3 Assessment (Section 4.5).
- Identification of future research needs (Chapter 5).

3. Guidance to Assessors

Before describing the approach that assessors should adopt to undertake a Stage 3 Assessment of RSAs on a Natura 2000 site, it is important that the reader understands the following points.

- It is recommended that the impact assessment approach focuses on estimating dose rates to species identified in the EA Habitats Handbook (EA, 2002) because of the difficulties associated with defining an approach to protect whole habitats or ecosystems. This is because, using the tools currently available, it is possible to assess impact only at the organism level.
- Therefore the species listed in EA (2002) are referred to in this report as feature species and are the focus of the assessment approach.
- In addition to the feature species, a number of habitats have been identified within EA (2002). These are referred to as feature habitats. However, many of these feature habitats have no feature species associated with them and cannot be assessed using the approach outlined in this report, although it may be desirable to demonstrate adequate protection is in place.
- Species that are representative of these feature habitats, hereafter known as key component species, have been identified following a review of literature on the conservation of these feature habitats.
- The assessment could be extended to include these key component species of the feature habitats present at each Natura 2000 site. Although this was outside the scope of this project, key component species from the feature habitats have been identified, where possible, for each of the Natura 2000 sites, and are listed on the site information sheets (Appendix 4) in case an assessor wishes to consider this further.

Figure 3.1 presents the impact assessment approach as a flow chart. Its aim is not only to explain the way the report is constructed, but to guide future assessors who may be faced with assessing the impact of an authorisation not identified in Appendices 1 and 2, or who are faced with a new Natura 2000 site.

The actual impact assessment approach adopted is based on the dose assessment methodology outlined within R&D Publication 128. This included dose assessment spreadsheets for three 'ecosystems' and a range of radionuclides:

- **Coastal and freshwater ecosystems:** ^{3}H, ^{14}C, ^{99}Tc, ^{90}Sr, ^{137}Cs, $^{239+240}Pu$, ^{238}U, ^{129}I, ^{60}Co, ^{106}Ru, ^{131}I, ^{234}Th, ^{234m}Pa, ^{241}Am, ^{32}P and ^{210}Po, using Coastal aquatic ecosystem release version 1.15 (final).xls and Freshwater ecosystem release version 1.15 (final).xls.

- **Terrestrial ecosystem:** ^{3}H, ^{14}C, ^{35}S, ^{90}Sr, ^{137}Cs, $^{239+240}Pu$, ^{238}U, ^{129}I, ^{210}Po, ^{41}Ar, ^{60}Co, ^{106}Ru, ^{131}I, ^{234}Th, ^{234m}Pa, ^{241}Am, ^{32}P and ^{85}Kr, using Terrestrial ecosystem release version 1.20 (final).xls.

The version number is important because there has been an upgrade to the coastal and freshwater spreadsheets to include seven additional radionuclides. There have been two upgrades for the terrestrial spreadsheet, resulting in nine additional radionuclides being incorporated into the calculations. The actual operation of the three spreadsheets will not be considered in this report; please refer to the R&D Publication 128ís appended CD with operating guide and supporting spreadsheets.

Within the dose assessment spreadsheets, a number of reference organisms were identified. These are listed in Table 3.1. Reference organisms are defined as:

> *"A series of entities that provide a basis for the estimation of radiation dose rate to a range of organisms which are typical, or representative, of a contaminated environment. These estimates, in turn, would provide a basis for assessing the likelihood and degree of radiation effects." (Larsson et al., 2002).*

It is important to understand that each reference organism in the spreadsheets consists of three components:

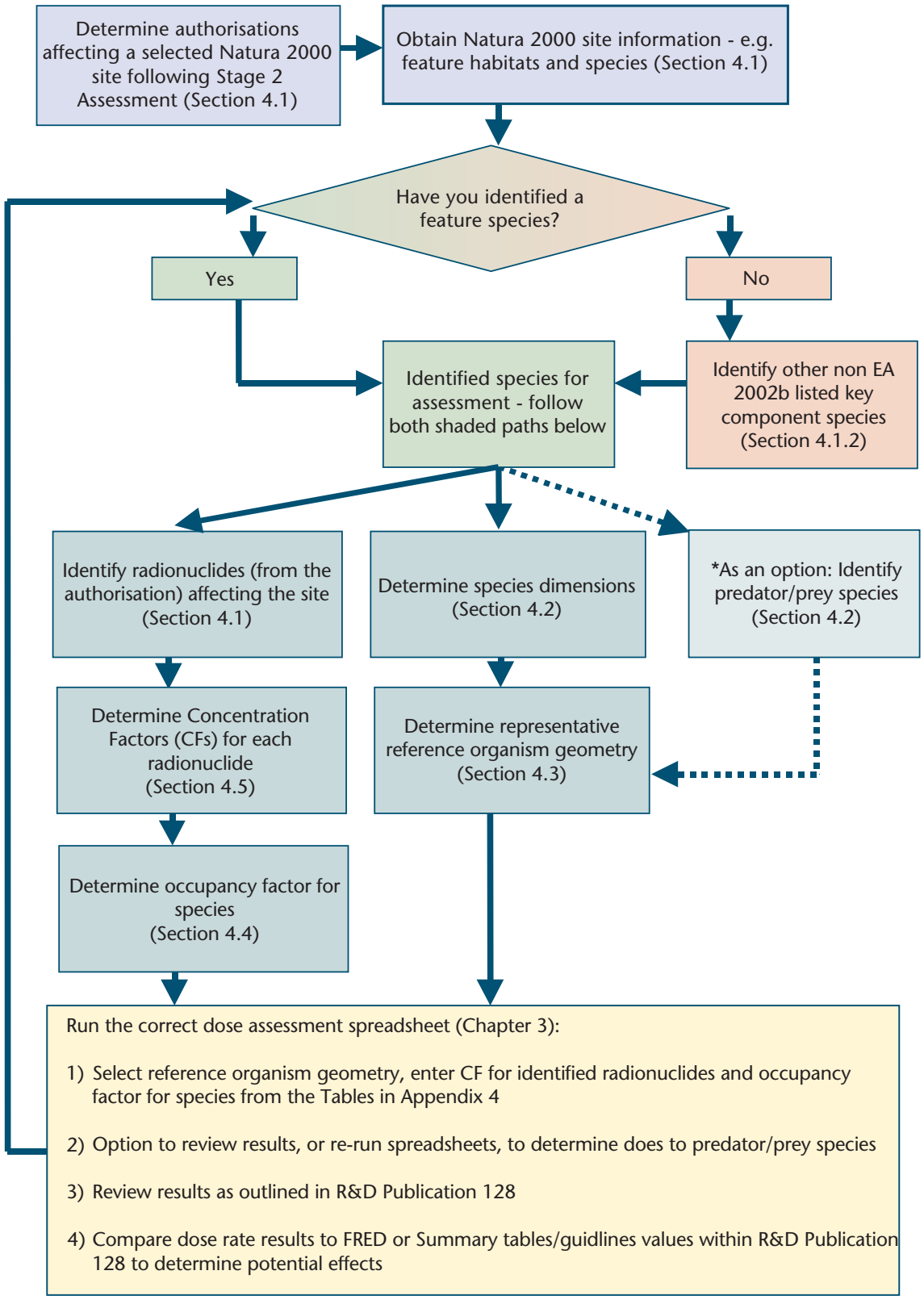
- a specific geometry (which is used to define a dose per unit concentration (DPUC) value);
- a concentration factor for a typical or representative species for that particular reference organism;
- occupancy factors for the time spent by that organism in different parts of the ecosystem.

So in Table 3.1, for example, a default pelagic fish in the coastal spreadsheet has a particular set of dimensions (45cm x 8.7cm x 4.9cm) and is represented by the species cod for determining its occupancy factors and concentration factors. It is important to realise that the recommended approach outlined in the following sections has then:

- determined the most suitable and appropriate specific geometry (from those available within R&D Publication 128) in order to derive a DPUC value; and
- determined concentration factors and occupancy factors on the basis of the ecology of the feature species.

Thus we might recommend that a feature species (such as a Marsh Harrier) should be represented by a benthic fish. This may appear illogical, but it is important to recognise that we are only considering the pelagic fish as a geometry (with sizes 45cm x 8.7cm x 4.9cm) for the purposes of dosimetry. New concentration factors and occupancy factors are recommended, and indeed required, for the Marsh Harrier before the dose rates can be calculated. These new concentration factors and occupancy factors are based on the ecology of the feature species and are given in Appendix 4. In order to run the dose rate calculations, the representative reference organism (geometry) for the feature species should be selected and the new concentration factors and occupancy factors input into the spreadsheet for this reference organism.

Figure 3.1 | Flow chart of the assessment process



* Note. Assessments in this report are restricted only to species listed under EA Handbook (2002). However other species information has been identified and incorporated in Appendix 3 Tables

Table 3.1 Selected reference organisms for each ecosystem dose assessment spreadsheet from R&D Publication 128

Freshwater	Coastal	Terrestrial
Bacteria	Bacteria	Bacteria
Macrophyte	Macrophyte	Lichen
Phytoplankton	Phytoplankton	Tree
Zooplankton	Zooplankton	Shrub
Benthic Mollusc	Benthic Mollusc	Herb
Small Benthic crustacean	Small Benthic crustacean	Seed
Large Benthic crustacean	Large Benthic crustacean	Fungus
Pelagic fish	Pelagic fish	Caterpillar
Benthic fish	Benthic fish	Ant
Amphibian	Fish egg	Bee
Duck	Seabird	Woodlouse
Aquatic mammal	Seal	Earthworm
	Whale	Herbivorous mammal
		Carnivorous mammal
		Rodent
		Bird
		Bird egg

3.1 Overview of the assessment process

The following section briefly summarises the approach to be undertaken for Stage 3 Assessments. The data required for the assessment are highlighted, in case an assessor has to follow a similar procedure for a site/authorisation not covered within this project. This information is listed in Appendix 4. Similarly, the following approach may be adopted if the assessor decides to evaluate the feature habitat through the use of identified key component species, which are not listed in EA (2002). The flow chart in Figure 3.1 identifies the main steps in the assessment and these are expanded further below.

a) Identify the Natura 2000 site of interest and the associated RSA details (Section 4.1 and Appendix 4). Note that there may be multiple Sites of Special Scientific Interest (SSSI) or National Nature Reserve (NNR) sites within SPAs or SACs that require assessment.

b) Determine the radionuclides that require assessment (usually determined within a Stage 2 Assessment and covering all radionuclides in the discharge) (Section 4.1 and Appendix 4).

c) Identify the species that are to be protected or that are representative of the feature habitat to be considered via EA (2002). There is the option to consider other species that are representative key components of feature habitats as indicated previously; these should be recorded for future use (Section 4.1 and Appendix 4).

d) Optionally, identify any predator/prey of the species listed in c) above (Section 4.2, Tables 4.1 and 4.2) and determine the dose rates for the appropriate predator/prey reference organisms selected from the appropriate dose assessment spreadsheet (see Appendix 3). For example, if a bird species feeds on marine invertebrates, the assessor might consider the mollusc and possibly small benthic crustacean groups from the coastal dose assessment spreadsheets.

e) Identify the dimensions of the species listed in c) (Section 4.3, Table 4.5).

f) Determine appropriate reference organism geometry from one of the three ecosystem spreadsheets for the species listed in c) (Section 4.3). For example, if a Brook lamprey is identified, then by checking Section 4.3, Table 4.6 it can be seen that the duck reference organism geometry from the freshwater spreadsheet is an appropriate shape for the dosimetric calculations. This will also identify the ecosystem spreadsheet for use.

g) Determine occupancy factors for the species listed in c) (Section 4.4, Table 4.7).

h) Identify relevant concentration factors for the radionuclides identified in b) to each of the species identified in c). Refer to Section 4.5 for further information on the derivation of concentration factors.

i) Run the assessment spreadsheet in accordance with the information provided in R&D Publication 128 amending as necessary the concentration and occupancy factors identified in g) and h) for the reference organism selected in step f). Then, depending upon the reference organism geometry selected for that predator/prey, either immediately consider the predator/prey reference organism groups identified in d), or re-run the spreadsheet using the default concentration and occupancy factors to identify the dose to the predator/prey organisms.

j) Compare the dose rates calculated with literature, such as the R&D Publication 128, or the FASSET Radiation Effects Database (FRED) (Woodhead and Zinger, 2003) on the likely impact of exposure on different wildlife groups and compare with the assessment values outlined in the Environment Agencyís guidance.

k) Repeat as necessary for each species identified in c).

Note that default values for concentration factors and occupancy factors from literature sources such as R&D Publication 128 should be adequate for the initial purposes of any assessment of the predator/prey, likewise, with the recommended concentration factor data in Appendix 4. However, where site-specific or species-specific data exist, this should always be used in preference to default or recommended values.

The concentration factor and occupancy factor information, along with the best representative reference organism geometry from R&D Publication 128, has been provided in each site information sheet (Appendix 4) to facilitate any assessor undertaking a Natura 2000 site assessment.

3.1.1 Practical demonstration

Following through the above guidance for a site in the EA Anglian region (see Appendix 4, Anglian pdf file), here is an example of he assessment process to follow.

a) Identify the Natura 2000 site of interest, the associated RSA details and the ecosystems in which the assessments are to be conducted	eg Ouse Washes and AL0419, AW3619, AZ0896, BB4111, BF8330, BI2842, BJ3578, BK3212, BL0332, BL4982, BM4988, AM7664, AW9714, AZ8447, BB6556, BG7029, BI3083, BJ3713, BK3735, BL1690, BL8856, BM7006, AS8457, AY1757, BA2768, BB9555, BG9838, BI6171, BJ5309, BK5843, BL3617, BL9887, BQ2758, AT3957, AY3903, BA6046, BB9563, BH3673, BI8204, BJ6372, BK7218, BL4451, BL9925, AW0725, AY6767, BA8642, BF3583, BI0432, BJ1273,BJ8006, BK8354, BL4729, BM0702 Freshwater and coastal assessments required
b) Determine the radionuclides	^{99m}Tc, ^{137}Cs, ^{90}Sr, ^{131}I, ^{14}C, ^{238}U
c) Identify feature species that require protection	Feature species: Bewicks swan, *Cygnus columbianus bewickii* Black-tailed godwit, *Limosa limosa* Cormorant, *Phalacrocorax carbo* Gadwall, *Anas strepera* Hen harrier, *Circus cyaneus* Lapwing, *Vanellus vanellus* Pintail, *A. acuta* Ruff, *Philomachus pugnax* Shoveler, *A. clypeata* Spined loach, *Cobitis taenia* Teal, *A. crecca* Tufted duck, *Aythya fuligula* Whooper swan, *C. cygnus* Wigeon, *A. penelope* No additional key component species identified. Follow the guidance now for one species only, and then repeat for all the others. For Bewicks swan: follow special guidance in the next steps.

d) Optionally, identify any predator/prey of the species listed in c). Determine the dose rate for the appropriate predator/prey reference organisms selected from the appropriate dose assessment spreadsheet.	See Tables 4.1 and 4.2. In this case, the prey items for the Bewicks swan include: Macrophyte Run both the freshwater and coastal dose assessment spreadsheets using the default parameter values, and record the dose rates for the above wildlife group(s) for inclusion in the assessment.
e) Identify the dimensions of the species listed in c) (Section 4.3, Table 4.5).	A Bewick swan's dimensions are: Length: 60cm (less tail and bill), 120cm (including tail and bill) Wingspan: 180-210 cm Body width: up to 80cm Weight: 4.9-7.8kg
f) Determine appropriate reference organism geometry from one of the three ecosystem spreadsheets for the species listed in c) (Section 4.3).	The Bewicks swan is represented by the seal reference organism geometry in the coastal spreadsheet.
g) Determine occupancy factors for the species listed in c) (Section 4.4, Table 4.7).	Occupancy factors for a Bewicks swan are: Sediment: 0 Sediment surface: 0.3 Water: 0.5
h) Identify relevant concentration factors for the radionuclides identified in b) to each of the species identified in c).	Concentration factors for the radionuclides listed in b) for a Bewicks swan are (for use in the coastal spreadsheet): ^{99m}Tc 8.0E+00 ^{137}Cs 3.0E+00 ^{90}Sr 1.0E+00 ^{131}I 3.0E+00 ^{14}C 2.0E+01 ^{238}U 1.0E+00
i) Run the assessment spreadsheet, based on step g) in accordance with the information provided in R&D Publication 128, amending as necessary the concentration and occupancy factors identified in f) and h) for the reference organism selected in step g).	Run the coastal dose assessment spreadsheet amending the occupancy and concentration factors as above for the seal reference geometry. Record the dose rate calculated for later use. Repeat the dose assessment spreadsheet run, using the default parameters to calculate the dose rate for the predator/prey wildlife groups identified in d). Record for later use.
j) Compare the dose rates calculated with the Summary Tables from the FASSET Radiation Effects Review (Woodhead and Zinger, in press) and R&D Publication 128 on the likely impact of exposure on different wildlife groups, and compare with the assessment values outlined in the Environment Agency guidance.	Compare the dose rates for the feature species and the prey species to the summary information available from FASSET and R&D Publication 128 and compare dose rates against Environment Agency guideline value. This will provide an indication of any likely impact on the species or wildlife group(s) at the dose rates calculated.

k) Repeat as necessary for each species identified in c).	Repeat for:	Black-tailed godwit, *Limosa limosa* Cormorant, *Phalacrocorax carbo* Gadwall, *Anas strepera* Hen harrier, *Circus cyaneus* Lapwing, *Vanellus vanellus* Pintail, *A. acuta* Ruff, *Philomachus pugnax* Shoveler, *A. clypeata* Spined loach, *Cobitis taenia* Teal, *A. crecca* Tufted duck, *Aythya fuligula* Whooper swan, *C. cygnus* Wigeon, *A. penelope*

3.2 Specific points to consider during the dose calculations

It has been difficult to collate all the necessary information on the sites requiring assessment. Discrepancies have been identified between the sites requiring assessment (Appendix 1) and the Environment Agency Habitats Database, which contains a wide range of information on Natura 2000 sites as weel as consents, permissions and activities pertinent to this area of work. Wherever possible, where there are discrepancies, data from both sources have been included in the site information sheets.

Assessors are therefore strongly advised to review the information contained on the site information sheets (Appendix 4) of their interest, especially with regard to the radionuclides that require further assessment following Stage 2.

There are, essentially, three levels of complexity when looking at the assessment of ecosystems as a whole, as written in EA (2002):

a) to consider feature habitats in their entirety;

b) to consider the component species and their predator/prey species within those feature habitats; or

c) to consider component species only, either as EA (2002) species only, or also by including species representative of key components of feature habitats (eg those listed in JNCC descriptions). The approach adopted in this report covers only the feature species listed in EA (2002). However, by considering the predator/prey of those species using the default values (eg for concentration and occupancy factors) in the assessment spreadsheets, some idea of the impact on the ecosystem as a whole may be obtained. It should be recognised that this will not provide a complete assessment of all the component parts of the feature habitats under assessment. Within the assessment, there are likely to be issues raised over the following points:

a) The treatment of organically bound ^{3}H (OBT) as identified in R&D Publication 128.Furthermore, there are a number of assumptions reported in R&D Publication 128 that should be considered (see Section 6.7 in R&D Publication 128). For example, it is known that 20-35% of the ^{3}H in wildlife organisms in continental ecosystems is in the form of OBT (FASSET deliverable D6, in preparation). This will result in the under-prediction of the ^{3}H concentrations by a similar percentage. Consequently the more OBT that is present, the greater the under-prediction that will result.

b) When considering the appropriate geometrical shape for the reference organisms, it should be remembered that the reference organism geometries in R&D Publication 128 are all based on an ellipsoid. Thus a cylindrical shape, which may best represent a feature species such as a lamprey, cannot be used. This may lead to uncertainties in the dose assessment for some species. However, previous work comparing doses to humans calculated using the ICRP method (which takes shape into account) and using both ellipsoid and cylindrical body shape for determining the doses from ^{41}Ar and ^{85}Kr, has demonstrated that the results are within a factor of two (Vives, 2003) and therefore any uncertainties are likely to be small compared with the overall assessment.

c) The use of analogues for both dosimetric and environmental transfer processes should be avoided wherever possible. As this is not always possible, we have adopted the following procedure for dealing with the use of analogues.

We have used analogues only to represent environmental dispersion and accumulation processes. This is indicated where necessary in Section 4.5.
We have assumed that the assessor will have concentration data for soil, air, water and sediment, and possibly biota, either from direct measurements or through the use of dispersion modelling tools. In this way, the assessor is strongly advised to review the CF values given in the site information sheets where additional data are available and to make appropriate changes to the input data for the dose assessment spreadsheets as advised in R&D Publication 128.

d) Radionuclides giving rise to potential impact are listed in Appendix 1. In some cases however, these are listed as ìother alphaî or ìother betaî. It is not possible to identify specifically the radionuclide or radionuclides that form these categories. We therefore recommend the following:

Using information available on the authorised discharges, and knowledge of the industrial process involved, the assessor should determine the likely candidate radionuclides. The assessment should then be run for each candidate radionuclide.
In the absence of specific information about the discharge and knowledge of the industrial process, we have made recommendations regarding the radionuclide to be used in the assessment (Section 4.5 and Appendix 4). These radionuclides have been selected using a precautionary approach.

e) Assessors should note that if good quality measurements of radionuclides in some or all of the relevant media (soil, sediment, water, air and biota) exist at the site under investigation, the uncertainty associated with the assessment approach outlined in Chapter 3 is likely to be reduced significantly.

f) In absence of concentration factors being available, an approach has been outlined in Section 4.5 which provides a mechanism for determining a conservative concentration factor for each radionuclide present in the dose assessment spreadsheets.

4. Supporting Information

To undertake a Stage 3 Assessment, it is necessary to know which Natura 2000 sites may potentially be impacted by the RSAs. The feature species and habitats requiring protection in these Natura 2000 sites must also be identified. Furthermore, these species need to be represented by appropriate reference organisms, listed in R&D Publication 128 dose assessment spreadsheets, to calculate dose rates to the species of interest. Occupancy factors for each species, based on an understanding of their ecology, must be identified. Finally, concentration factors for the radionuclides that may be impacting a Natura 2000 site and its species need to be determined.

In many cases, this information is lacking, and a suitable approach is needed to permit an initial Stage 3 Assessment to be undertaken. It is emphasised again that an assessor should consider the above, but wherever site-specific data exist (for example, on radionuclide concentrations in biota) they should be used in preference to the data listed in Appendix 4.

The supporting information required for the Stage 3 Assessment has been identified under the following sections.

4.1 - Identification of species and habitats to be protected within Natura 2000 sites potentially affected by the RSAs.

4.2 - Review species characteristics.

4.3 - Representation of species by R&D Publication 128 reference organism geometries.

4.4 - Evaluation of the literature to identify appropriate occupancy factors for use in the Stage 3 Assessment.

4.5 - Derivation of Concentration Factors (CFs) for use in the Stage 3 Assessment.

The aim is to support, with stated assumptions and uncertainties, the guidance described in Chapter 3. **Note that assumptions relating to the actual dose estimation methodology are given in R&D Publication 128.**

4.1 Data on the Natura 2000 sites potentially affected by RSAs

Details such as the site name, site priority, permissions influencing the site, radionuclides of concern and habitat affected by the permission (marine, freshwater or terrestrial) were provided by the Environment Agency (Appendix 1). Additional and confirmatory data, along with information on the feature species and feature habitats listed at each Natura 2000 site potentially affected by an RSA authorisation, were extracted from the National Habitat Directives System version 1, held by the Environment Agency in the form of a database.

All of these data have been incorporated into the information sheets for each Natura 2000 site (Appendix 4). These information sheets, catalogued for each EA region, contain all the information pertinent to carrying out the Stage 3 Assessment by Environment Agency staff (see Chapter 3).

In the context of this report, a feature species can be defined as:

> *Named species that has been identified as requiring protection in Agency guidance on the Habitats Directive; see Appendix 13 (Habitats and species protected under the Habitats and Birds Directives) of EU Habitats Directive and Regulations Process Handbook for Agency Permissions and Activities.*

It is important to recognise that the methodology outlined in R&D Publication 128 determines dose rates for defined reference organisms. These reference organisms are essentially geometric shapes (for the purposes of the dosimetry calculations) and have been linked to typical, common organism types for determining the uptake and transfer of radionuclides through different trophic levels. The reference organisms can therefore be considered analogous to individual species. Hence, the Stage 3 Assessment process will be undertaken by stylising the feature species to the reference organisms listed in R&D Publication 128. Chapter 3 describes this in more detail.

In the context of this report, a feature habitat can be defined as:

A named habitat that has been identified as requiring protection in Agency guidance on the Habitats Directive; see Appendix 13 (Habitats and species protected under the Habitats and Birds Directives) of EU Habitats Directive and Regulations Process Handbook for Agency Permissions and Activities.

It is important however to realise that these feature habitats may have been designated for reasons other than the conservation status of species that they contain (eg for their physical features). Because of this, the key component species for these feature habitats may be different to those feature species listed in EA (2002). The scope of this project was to consider only those species listed in EA (2002) that are present at sites potentially impacted by RSAs. In addition, it should be emphasised that the R&D Publication 128 methodology is designed to determine doses to biota and not to physical characteristics such as those used to designate some of the feature habitats listed in EA (2002).

4.1.1 Identification of feature species

EA (2002) lists a number of SAC habitats, SAC species groups, SPA bird species, European protected species of animals and plants, and a list of animals that cannot be taken or killed. A total of 51 sites were identified as requiring a Stage 3 Assessment. From these 51 sites, 81 species listed in EA (2002) were identified as needing protection of which there were:

- 55 bird species (Table 4.1);
- four plant species (Table 4.2);
- two terrestrial invertebrate species (Table 4.2);
- two amphibian species (Table 4.2);
- four terrestrial mammal species (Table 4.2);
- three aquatic mammal species (Table 4.2);
- one aquatic invertebrate species (Table 4.2);
- eight fish species (Table 4.2);
- two reptile species (Table 4.2);
- 35 feature habitats were also identified for consideration (Table 4.3).

Table 4.1 Bird species listed in EA (2002) for Natura 2000 sites potentially impacted by RSAs.

Feature species (common name)	Feature species (Latin name)	Habitat (C=coastal, F=freshwater T=terrestrial)[1]	Simplified prey item categories identified from literature (order does not reflect dietary importance)[2]	Suggested equivalent prey reference organism from R&D Publication 128[3]
Avocet	*Recurvirostra avosetta*	C F	Insect, crustacean, worm Insect, crustacean, worm	Benthic mollusc, small crustacean Benthic mollusc, small crustacean
Bar-tailed godwit	*Limosa lapponica*	C F	Insect, snail, worm Insect, snail, worm	Benthic mollusc, small crustacean Benthic mollusc, small crustacean
Bewicks swan	*Cygnus colmbianus*	C F T	Plant Plant Plant, seed	Macrophyte Macrophyte Herb, seed

[1,2,3] See footnotes on page 24

Table 4.1 | Continued

Feature species (common name)	Feature species (Latin name)	Habitat (C=coastal, F=freshwater T=terrestrial)[1]	Simplified prey item categories identified from literature (order does not reflect dietary importance)[2]	Suggested equivalent prey reference organism from R&D Publication 128[3]
Bittern	*Botaurus stellaris*	C	Fish, insect, worm	Benthic mollusc, pelagic fish, small crustacean
		F	Fish, frog, insect, worm	Amphibian, benthic mollusc, pelagic fish, small crustacean
Black-tailed godwit	*Limosa limosa*	C	Insect, snail, worm	Benthic mollusc, small crustacean
		F	Insect, snail, worm	Benthic mollusc, small crustacean
		T	Insect, snail, worm	Ant, bee, earthworm
Brent goose	*Branta bernicla*	C	Plant	Macrophyte
		F	Plant	Macrophyte
		T	Plant	Herb
Chough	*Pyrrhocorax pyrrhocorax*	C	Insect	Benthic mollusc, small crustacean
		T	Insect, worm	Ant, bee, earthworm
Common scoter	*Melanitta nigra*	C	Mollusc	Benthic mollusc
		F	Mollusc	Benthic mollusc
Common tern	*Sterna hirundo*	C	Fish	Pelagic fish
Cormorant	*Phalacrocorax carbo*	C	Fish	Pelagic fish
		F	Fish	Pelagic fish
Curlew	*Numenius arquata*	C	Crustacean, mollusc, worm	Benthic mollusc, small crustacean
		F	Crustacean, mollusc, worm	Benthic mollusc, small crustacean
		T	Worm	Earthworm
Dartford warbler	*Sylvia undata*	T	Insect	Ant, bee
Dunlin	*Calidris alpina*	C	Crustacean, insect mollusc, worm	Benthic mollusc, small crustacean
		F	Crustacean, insect mollusc, worm	Benthic mollusc, small crustacean
		T	Crustacean, insect mollusc, seed, worm	Ant, bee, earthworm, seed
Gadwall	*Anas strepera*	C	Plant	Macrophyte
		F	Plant	Macrophyte
		T	Plant, seed	Herb, seed
Gannet	*Sula bassana*	C	Fish	Benthic fish, pelagic fish
Golden plover	Pluvialis apricaria	C	Insect, worm	Benthic mollusc, small crustacean
		F	Insect, worm	Benthic mollusc, small crustacean
		T	Insect, worm	Ant, bee, earthworm

[1]Species living in the marine environment have been recorded as coastal. The terms coastal, freshwater and terrestrial refer to the availability of the dose assessment spreadsheets from R&D Publication 128 and should not be considered accurate assessments of the ecosystem type for a particular organism.

[2]Predators and prey associated with each feature species were not the primary focus of this study. The information presented here was obtained from a brief search of available literature and should be viewed as indicative only. Should the identification of predators and prey become an essential component of the assessment, then a more detailed investigation of food web linkages associated with each species in each ecosystem is highly recommended. A bibliography of the reviewed literature is included in the reference section. The simplified categories have been used only for the purpose of identifying R&D Publication 128 reference organisms which, in our opinion, should be evaluated using the default settings in the dose assessment spreadsheets because of biological similarities.

[3]Equivalent prey reference organisms have been selected on the basis of the geometry of the reference organism and its potential similarity in terms of radionuclide uptake.

Table 4.1 | Continued

Feature species (common name)	Feature species (Latin name)	Habitat (C=coastal, F=freshwater T=terrestrial)[1]	Simplified prey item categories identified from literature (order does not reflect dietary importance)[2]	Suggested equivalent prey reference organism from R&D Publication 128[3]
Great crested grebe	*Podiceps cristatus*	C F	Fish Fish	Pelagic fish Pelagic fish
Grey plover	*Pluvialis squatarola*	C F T	Crustacean, worm Crustacean, worm Insect, worm	Benthic mollusc, small crustacean Benthic mollusc, small crustacean Ant, bee, earthworm, woodlouse
Guillemot	*Uria aalge*	C	Crustacean, fish	Benthic fish, large benthic crustacea, pelagic fish
Hen harrier	Circus cyaneus	C F T	Bird Bird, mammal Bird, mammal	Seabird Duck, aquatic mammal Bird, herbivorous mammal
Honey buzzard	*Pernis apivorus*	T	Insect	Ant, bee, caterpillar
Kittewake	*Rissa tridactyla*	C T	Crustacea, fish Worm	Pelagic fish, small benthic crustacea Earthworm
Knot	*Calidris canuta*	C F T	Crustacean, worm Crustacean, worm Insect, worm	Benthic mollusc, small crustacean Benthic mollusc, small crustacean Ant, bee, earthworm, woodlouse
Lapwing	*Vanellus vanellus*	C F T	Insect, worm Insect, worm Insect, worm	Benthic mollusc, small crustacean Benthic mollusc, small crustacean Ant, bee, earthworm
Lesser black-backed gull	*Larus fuscus*	C F T	Invertebrate, fish, bird Invertebrate, fish Bird, invertebrate, mammal	Benthic mollusc, pelagic fish, small crustacean, seabird Benthic mollusc, pelagic fish, small crustacean Ant, bee, bird, earthworm, rodent, woodlouse
Little tern	*Sterna albifrons*	C	Fish, invertebrate	Benthic mollusc, pelagic fish, small crustacean
Manx shearwater	*Puffinus puffinus*	C	Fish	Pelagic fish
Marsh harrier	*Circus aeruginosus*	C F T	Bird Bird, mammal Bird, mammal	Seabird Aquatic mammal, duck Bird, rodent
Mediterranean gull	*Larus melanocep-halus*	C F T	Invertebrate, fish, bird Invertebrate, fish Bird, invertebrate, mammal	Benthic mollusc, pelagic fish, small crustacean, seabird Benthic mollusc, pelagic fish, small crustacean Ant, bee, bird, earthworm, rodent, woodlouse
Nightjar	*Caprimulgus europaeus*	T	Insect	Ant, bee

[1,2,3] See footnotes on page 24

Table 4.1 | Continued

Feature species (common name)	Feature species (Latin name)	Habitat (C=coastal, F=freshwater T=terrestrial)[1]	Simplified prey item categories identified from literature (order does not reflect dietary importance)[2]	Suggested equivalent prey reference organism from R&D Publication 128[3]
Oystercatcher	*Haematopus ostralegus*	C F T	Mollusc, worm Mollusc, worm Worm	Benthic mollusc, small crustacean Benthic mollusc, small crustacean Earthworm
Peregrine falcon	*Falco peregrinus*	C T	Seabird Bird	Seabird Bird
Pink-footed goose	*Anser brachy-rhynchus*	C F T	Plant Plant Grass, plant, seed	Macrophyte Macrophyte Herb, seed
Pintail	*Anas acuta*	C F T	Invertebrate, plant Invertebrate, plant Invertebrate, plant, seed	Benthic mollusc, macrophyte, small crustacean Benthic mollusc, macrophyte, small crustacean Ant, bee, earthworm, Herb, seed, woodlouse
Puffin	*Fratercula arctica*	C	Fish	Benthic fish
Razorbill	*Alca torda*	C	Fish	Benthic fish, pelagic fish
Redshank	*Tringa totanus*	C F T	Insect, crustacean, mollusc, worm Insect, crustacean, mollusc, worm Insect, worm	Benthic mollusc, small crustacean Benthic mollusc, small crustacean Ant, bee, earthworm, woodlouse
Ringed plover	*Charadrius hiaticula*	C F T	Insect, crustacean, mollusc, worm Insect, crustacean, mollusc, worm Insect, crustacean, mollusc, worm	Benthic mollusc, small crustacean Benthic mollusc, small crustacean Ant, bee, earthworm, woodlouse
Ruff	*Philomachus pugnax*	C F T	Insect, fish Insect, frog, fish Insect, seed	Benthic mollusc, pelagic fish, small crustacean Small crustacea, benthic mollusc, amphibian, pelagic fish Ant, bee, caterpillar, seed
Sanderling	*Calidris alba*	C F T	Crustacean, mollusc, worm Crustacean, mollusc, worm Insect, worm	Benthic mollusc, small crustacean Benthic mollusc, small crustacean Ant, bee, earthworm, woodlouse
Sandwich tern	*Sterna sandvicensis*	C	Fish	Pelagic fish
Scaup	*Aythya marila*	C F	Crustacea, insect Crustacea, insect	Benthic mollusc, small crustacean Benthic mollusc, small crustacean
Shelduck	*Tadorna tadorna*	C F	Crustacea, invertebrates, mollusc Crustacea, invertebrates, mollusc	Benthic mollusc, small crustacean Benthic mollusc, small crustacean
Short-eared owl	*Asio flammeus*	T	Mammal	Rodent

[1,2,3] See footnotes on page 24

Table 4.1 | Continued

Feature species (common name)	Feature species (Latin name)	Habitat (C=coastal, F=freshwater T=terrestrial)[1]	Simplified prey item categories identified from literature (order does not reflect dietary importance)[2]	Suggested equivalent prey reference organism from R&D Publication 128[3]
Shoveler	*Anas clypeata*	F T	Invertebrate, plankton, plant Invertebrate, plant, seed	Macrophyte, phytoplankton, small crustacean, zooplankton Ant, bee, earthworm, herb, seed, woodlouse
Snipe	*Gallinago gallinago*	C F T	Small invertebrates, worms Small invertebrates, worms, insects Small invertebrates, worms, insects	Benthic mollusc, small crustacean Benthic mollusc, small crustacean Ant, bee, earthworm, woodlouse
Stone curlew	*Burhinus oedicnemus*	T	Insect, worm,	Ant, bee, earthworm
Storm petrel	*Hydrobates pelagicus*	C	Crustacea, fish, zooplankton	Pelagic fish, small benthic crustacea zooplankton
Teal	*Anas crecca*	C F T	Invertebrate, plant Invertebrate, plant Invertebrate, plant, seed	Benthic mollusc, macrophyte, small crustacean Benthic mollusc, macrophyte, small crustacean Ant, bee, earthworm, herb, seed
Tufted duck	*Aythya fuligula*	C F	Insect, mollusc, plant Insect, mollusc, plant	Benthic mollusc, macrophyte, small crustacean Benthic mollusc, macrophyte, small crustacean
Turnstone	*Arenaria interpres*	C F	Crustacea, insect, mollusc Crustacea, insect, mollusc, worm	Benthic mollusc, small crustacean Benthic mollusc, small crustacean
White-fronted goose	*Anser albifrons*	C F T	Plant Plant Plant, seed	Macrophyte Macrophyte Herb, seed
Whooper swan	*Cygnus cygnus*	C F T	Plant Plant Plant, seed	Macrophyte Macrophyte Herb, seed
Wigeon	*Anas penelope*	C F T	Plant Plant Plant	Macrophyte Macrophyte Herb, seed
Woodlark	*Lullula arborea*	T	Insect, seed	Ant, bee, caterpillar, seed

[1,2,3] See footnotes on page 24

Table 4.2 Mammal, fish, amphibian, invertebrate and plant species listed in EA (2002), for Natura 2000 sites potentially impacted by RSAs.

Feature species (common name)	Feature species (Latin name)	Habitat (C=coastal, F=freshwater T=terrestrial)[1]	Prey items identified from literature (order does not reflect dietary importance)	Suggested equivalent prey reference organism from R&D Publication 128
Allis shad	*Alosa alosa*	C F	Fish, zooplankton Fish, zooplankton	Pelagic fish, zooplankton Pelagic fish, zooplankton
Atlantic salmon	*Salmo salar*	C F	Crustacea, insect Crustacea, insect	Benthic mollusc, small crustacean Benthic mollusc, small crustacean
Bechsteins bat	*Myotis myotis*	T	Insect	Ant, bee
Brook lamprey	*Lampetra planeri*	F	Algae, detritus, diatom, fish	Bacteria, benthic fish, pelagic fish, phytoplankton
Bullhead	*Cottus gobio*	F	Crustacea, insect	Benthic mollusc, small crustacean
Common seal	*Phoca vitulina*	C	Fish	Benthic fish, pelagic fish
Desmoulins whorl snail	*Vertigo moulinsiana*	F T	Plant Plant	Macrophyte Herb
Dormouse	*Muscardinus avellanarius*	T	Insect, plant	Ant, herb, seed
Early gentian	*Gentianella anglica*	F T		
Fen orchid	*Liparis loeselii*	F T		
Great crested newt	*Triturus cristatus*	F T	Insect, mollusc Insect, mollusc	Benthic mollusc, small crustacean Ant, bee, earthworm, woodlouse
Greater horseshoe bat	*Rhinolophus ferrumequinum*	T	Insect	Ant, bee
Grey seal	*Halichoerus grypus*	C	Fish	Benthic fish, pelagic fish
Lesser horseshoe bat	*Rhinolophus hipposideros*	T	Insect, spider	Ant, bee
Natterjack toad	*Bufo calamita*	F T	Algae, plant, zooplankton Crustacea, insect, gastropod, spider, worm	Macrophyte, phytoplankton, zooplankton Ant, bee, earthworm, woodlouse
Otter	*Lutra lutra*	C F T	Bird, fish, frog, mammal Bird, fish, frog, mammal Bird, mammal	Amphibian, aquatic mammal, benthic fish, duck, pelagic fish Amphibian, aquatic mammal, benthic fish, duck, pelagic fish Bird, rodent
Petal wort	*Petalophyllum ralfsii*	T		
River lamprey[2]	*Lampetra fluviatilis*	C F	Algae, detritus, diatom, fish Algae, detritus, diatom, fish	Bacteria, benthic fish, pelagic fish, phytoplankton Bacteria, benthic fish, pelagic fish, phytoplankton

[1]Species that are migratory are listed as occupying both freshwater and coastal habitats (see Section 4). These species are the Allis shad, Twaite shad, Atlantic salmon and River lamprey.

Table 4.2 | Continued

Feature species (common name)	Feature species (Latin name)	Habitat (C=coastal, F=freshwater T=terrestrial)[1]	Prey items identified from literature (order does not reflect dietary importance)	Suggested equivalent prey reference organism from R&D Publication 128
Sand lizard	*Lacerta agilis*	C F	Insect, slug, worm	Ant, bee, earthworm
Sea lamprey[3]	*Petromyzon marinus*	C F	Algae, detritus, diatom, fish Algae, detritus, diatom, fish	Bacteria, benthic fish, pelagic fish, phytoplankton Bacteria, benthic fish, pelagic fish, phytoplankton
Shore dock	*Rumex rupestris*	T		
Smooth snake	*Cornella austriaca*	T	Birds, reptile, small mammal	Bird, reptile, rodent
Southern damselfly	*Coenagrion mercuriale*	F	Crustacea, insect	Benthic mollusc, small crustacean
Spined loach	*Cobitis taenia*	F	Crustacea, insects	Benthic mollusc, small crustacean
Stag beetle	Lucanus cervus	T	Dead wood	Bacteria, fungi, tree
Twaite shad	*Alosa fallax*	C F	Fish, zooplankton Fish, zooplankton	Pelagic fish, zooplankton Pelagic fish, zooplankton

[1]See footnote on previous page
[2]Adult life stage parasitic

Table 4.3 | Feature habitats as listed in EA (2002) for Natura 2000 sites potentially impacted by RSAs, together with their identified key component species (from sources associated with JNCC and EN).

Feature habitat	Species associated with the feature habitat	Associated species that appear in EA 2002
Alkaline fens	None identified	
Annual vegetation of drift lines	*Honkenya peploides,* Sea beet - *Beta vulgaris* *Beta vulgaris spp., Maritima* and *orache Atriplex spp.*	
Atlantic salt meadows - *Glauco-Puccinellietalia*	Sea lavenders - *Limonium spp* Golden samphire - *Inula crithmoides* Sea purslane - *Atriplex portulacoides,* Common sea-lavender - *Limonium vulgare,* Thrift - *Armeria maritima, Spartina spp.*	
Beech forests with *Ilex* and *Taxus* rich in epiphytes - *Ilici-Fagion*	Beech - *Fagus sylvatica, Quercion roboripetraeae, Ilici-Fagenion*	Bechsteins bat - *Myotis bechsteini.,* Nightjar - *Caprimulgus europaeus*

Table 4.3 | Continued

Feature habitat	Species associated with the feature habitat	Associated species that appear in EA 2002
Bog woodland	Birch - *Betula spp.*, Willow - *Salix spp.*, Alder - *Alnus spp., Sphagnum spp.*	
Calcareous fens with *Cladium mariscus* and *Carex davalliana*	*Cladium,* Black bog-rush - *Schoenus nigricans, Tormentil Potentilla erecta,* Meadow thistle - *Cirsium dissectum,* Purple moor grass - *Molinia caerulea,* rush pastures, reedbeds.	Short-eared owl - *Asio flammeus,* Hen harrier - *Circus cyaneus,* Snipe - *Gallinago gallinago,* Teal - *Anas crecca,* Wigeon - *Anas penelope,* Shoveler - *Anas clypeata,* Tufted duck - *Aythya fuligula*
Depressions on peat substrates - *Rhynchosporion*	Brown mosses - *Cratoneuron spp., Scorpidium scorpioides*, Bog orchid - *Hammarbya paludosa,*	
Dry heaths (all subtypes)	Heather - *Calluna vulgaris,* Bell heather - *Erica cinerea*, Gorse - *Ulex gallii, Ulex minor, Agrostis curtisii, Molinia spp.*	Early gentian - *Gentianella anglica,* Sand lizard - *Lacerta angilis,* Smooth snake - *Coronella austriaca*
Dunes with Hippophae rhamnoides	Sea buckthorn - *Hippophae rhamnoides, Elder - Sambucus nigra*, Hawthorn - *Crataegus monogyna,* Ivy - *Hedera helix,* Marram - *Ammophila arenaria*	
Dunes with *Salix arenaria*	*Salix arenaria*	
Embryonic shifting dunes	None identified	
Estuaries	Reef building worm - *Sabellaria spinulosa,* Brittlestar - *Ophiothrix fragillis,* crustaceans and ascidians. Rare sponges. Polychaete - *Sabellaria spinulosa*	
Fixed dunes with herbaceous vegetation (grey dunes)	Red fescue - *Festuca rubra,* Pyramidal orchid - *Aanacamptis pyramidalis,* Bee orchid - *Orchis apifera,* Sea holly - *Eryngium maritimum,* Meadow rue - *Thalictrum minus,* Sea campion - *Silene maritime.* Ladiess' bedstraw - *Galium verum,* Marram - *Ammophila arenaria,* Sand sedge - *Carex arenaria,* Sheep's fescue - *Festuca ovina,* Common bent - *Agrostis capillaries* Rare lichens - *Fulgensia fulgens*	

Table 4.3 | Continued

Feature habitat	Species associated with the feature habitat	Associated species that appear in EA 2002
Floating vegetation of Ranunculus of plain and submountainous rivers - Water Courses of plain to montane levels with the Ranunculion fluviantis and Callitricho-Batrachion1566	Stream water crowfoot *(Ranunculus penicillatus spp. pseudofluitans),* River water crowfoot *(Ranunculus fluitans),* Pond water crowfoot *(Ranunculus peltatus), Callitriches obtusangula, Callitriche platycarpa*	
Hard oligo-mesotrophic waters with benthic vegetation of Chara formations	None identified	
Humid dune slacks	Fen orchid - *Liparis loeselii*	
Lagoons	Lagoonal mysid shrimp - *Paramysis nouveli* (nationally rare) Cockle - *Cerastoderma glaucum, Cyprideis torosa, Littorina saxatillid tenebrosa, Hydrobia ventrosa,* Scarlet sea anemone - *Nematostella vectensis* (nationally rare). Foxtail stonewort - *Lamprothamnium papulosum* (nationally rare), Lagoon sand shrimp - *Gammarus insensibilis* (nationally rare), Scarlet sea anemone *Nematostella vectensis* (nationally rare)	
Large shallow inlets and bays	Large numbers of polychaetes bivalve and crustaceans. *Sabellaria spinulosa* - Ross worm Narrow leaved eel grass - *Zostera angustifolia*	
Lowland hay meadows - *Alopecurus pratensis, Sanguisorba offinalis*	*Alopecurus pratensis, Sanguisorba offinalis, Fritillaria meleagris*	
Mediterranean and thermo-Atlantic halophilous scrubs - *Arthrocnemetalia fruticosae*	Sea blite - *Suaeda vera,* Sea purslane - *Atriplex portulacoides,* Perennial glasswork - *Sarcocornia perennis* *Limonium spp.,* Sea heath - *Frankenia laevis*	
Molinia meadows on chalk and clay	Purple moor grass - *Molinia aerulea,* Meadow thistle - *Cirsium dissectum*	Short-eared owl - *Asio flammeus,* Hen harrier - *Circus cyaneus,* Snipe - *Gallinago gallinago,* Teal - *Anas crecca,* Wigeon - *Anas penelope,* Shoveler - *Anas clypeata,* Tufted duck - *Aythya fuligula*

Table 4.3 | Continued

Feature habitat	Species associated with the feature habitat	Associated species that appear in EA 2002
Mudflats and sandflats not covered by seawater at low tide	Large numbers of polychaetes, bivalves and crustaceans. *Zostera spp.*	
Northern Altlantic wet heaths with *Erica tetralix*	*Erica tetralix*	
Perennial vegetation of stony banks	Sea pea - *Lathyrus japonicus*, False oat grass - *Arrhena therum elatius,* rich in lichens	
Reefs	Polychaete - *Sabellaria spinulosa,* Pink shrimp - *Pandalus montagui,* Crabs - *S. spinulosa.*	
Residual alluvial forests - *Alnion glutinoso-incanae*	Alder - *Alnus glutinosa,* Framentary ash - *Fraxinus excelsior, Quercus robur, Quercion robori-petraeae, Ilicic-Fagenion*	
Salicornia and other annuals colonising mud and sand	*Spartina spp* swards, *Salicornia. Spartina anglica* - Common cord grass, *Salicorna.*	
Sandbanks that are slightly covered by sea water all the time.	Brittlestars - *Ophiothrix fragilis,* Sand-mason worm - *Lanice conchilega,* Telling - *Angulus tenuis,* Plaice - *Pleuronectes platessa,* Cod - *Gadus morhua,* Sole - *Solea solea.*	
Semi-natural dry grasslands and scrubland facies: on calcareous substrates - *Festuco-Brometalia*	*Brchypodium pinnatum, Bromus erectus, Festuca ovina, Avenula pratensis,* Early spider orchid *(Ophrys sphegodes),* Late spider orchid *(Ophrys fuciflora),* Burnt orchid *(Orchis ustulata)* Fragrant orchid *(Gymnadenia conopsea).*	
Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)	*Amophilia,* Lyme grass - *Leymus arenarius,* Sand sedge - *Carex arenaria.*	
Spartina swards - Spartinion	*Spartinion maritimae, Salicornia.*	
Stellario-Carpinetum oak-hornbeam forests	Hornbam *(Carpinus betulus)* Pedunculates oak *(Quercus robur),* Sweet chestnut *(Castanea sativa),* Great wood-rush *(Luzula sylvatica),* Greater stitchwort *(Stellaria holoste),* Heath fritillary butterfly *(Mellicta athalea)*	

Table 4.3 | Continued

Feature habitat	Species associated with the feature habitat	Associated species that appear in EA 2002
Submerged or partly submerged sea caves	None identified	
Transition mires and quaking bogs	None identified	
Vegetated sea cliffs of the Atlantic and Baltic coasts	Thrift - *Armenia maritima,* Rock samphire - *Crithmum maritimum,* Bucks-horn Plantain - *Plantago coronopus,* Yellow whittlegrass - *Draba azoides,* Spring squill - *Scilia verna,* Small restharrow - *Ononis reclinata,* Early gentian - *Gentianella anglica,* Goldilocks - *Aster linosyris,* Sea lavender - *Limonium parvum,* Lichens - *Fulgensia fulgens*	

4.1.2 Feature habitats

Problems have been encountered in trying to represent feature habitats in a manner that would enable dose rate calculations to be conducted. The best approach to protecting a feature habitat would be to identify the key component species of that habitat and then to undertake the assessment process on these species. Initially, attempts were made to represent feature habitats as species listed in EA (2002), but this was not possible for a number of feature habitats (see Table 4.3). Consequently, attempts were made to identify key component species that were given in the descriptions for each feature habitat provided by sources such as the Joint Nature Conservation Committee (JNCC) and by extracting species information from details on specific SSSIs available from the English Nature website.

Two major problems were encountered with using key component species to represent these feature habitats:

a) It was felt that selecting species to represent these habitats may not capture the full essence of the habitat, which is the feature to protect, eg the feature habitat may be present because of the underlying geology. Although it should be noted that if the feature habitat being protected is physical (eg based on geology or geochemistry), the presence of radionuclides is unlikely to affect the habitat unless the radionuclide concentrations are exteremely high. Therefore if the conditions are tolerable for the default R&D Publication 128 reference organisms, we can be reasonably sure that physically-based features will be protected unless there are specific organisms involved in maintaining a particular habitat feature.

b) The range of potential species for consideration is large and outside of the scope of this project. For example, more than 100 plant species are recorded for specific habitat types under the National Vegetation Classification scheme (NVC) that might require consideration. No specific method for calculating the dose rate to and therefore estimating the impact of an authorised discharge on a protected feature habitat has been agreed between interested parties.

Consequently, the following approach has been adopted within this project.

- For each feature habitat, any species listed in the sources of information indicated (JNCC and English Nature) have been identified and recorded in Table 4.3.
- The species in Table 4.3 have been compared with those species listed in EA (2002).
- Those species specifically named (eg SAC or European protected species, SPA birds) and listed under the feature habitats in EA (2002) have been included in the assessment approach described in the remainder of this report.
- On the information sheet for each site requiring assessment (Appendix 4), the feature habitat and

any identified species have been listed to inform assessors (see Chapter 3) about other species that may need to be considered in the future (see Chapter 5 (research requirements)). Note that under each SPA or SAC there may be multiple SSSI or NNR sites that require independent assessment because they contain different feature species ñ hence there may be multiple information sheets for each SPA or SAC.

4.2 Review of species characteristics

4.2.1 Species characteristics

Ecological information on each identified feature species was obtained. This included organism dimensions, principal prey, predator, and occupancy factors for different parts of the ecosystems under investigation. This information was obtained from a number of different sources including JNCC, the Royal Society for the Protection of Birds (RSPB) and English Nature, as well as the scientific literature (see bibliography). The collated information is summarised in Tables 4.1, 4.2 and 4.7.

4.3 Representation of species by R&D Publication 128 reference organism geometries

This section provides information on how to represent feature organisms by the reference organism geometries listed in R&D Publication 128 in order to carry out dose assessments. A method has been devised which relates the geometry of a new organism to the nearest geometry available in R&D Publication 128 in terms of the area/volume ratio, assuming an abstracted ellipsoid geometry. The following section describes the dependency found between dose per unit concentration (DPUC) and the area/volume parameter. Based on this, a method to identify candidate R&D Publication 128 reference organisms is given, along with a simplified way to represent uncertainty. A proposed equivalence between feature species and reference geometries of R&D Publication 128 is presented at the end of the section.

4.3.1 Analysis of geometry dimensions

Dose Per Unit Concentration (DPUC) values for the full range of R&D Publication 128 radionuclides (^{3}H, ^{14}C, ^{32}P, ^{35}S, ^{41}Ar total and y, ^{60}Co, ^{85}Kr total and y, ^{90}Sr, ^{95}Zr, ^{95}Nb, ^{99}Tc, ^{106}Ru, ^{125,129,131}I, ^{134,137}Cs, ^{144}Ce, ^{210}Po, ^{226}Ra, ^{234}Th/^{234m}Pa, ^{238}U, ^{238,239,241}Pu, and ^{241}Am) were plotted and analysed in order to determine whether there was a relationship between feature species and reference organism dimensions, see examples in Figure 4.1. A possible dependence between DPUC and the area per unit volume parameter was established after a number of trials.

For the terrestrial organisms in R&D Publication 128, least squares linear and log-log linear (a representation equivalent to a power function) fittings between DPUC and area/volume were calculated for each radionuclide. The main findings of this exercise were as follows.

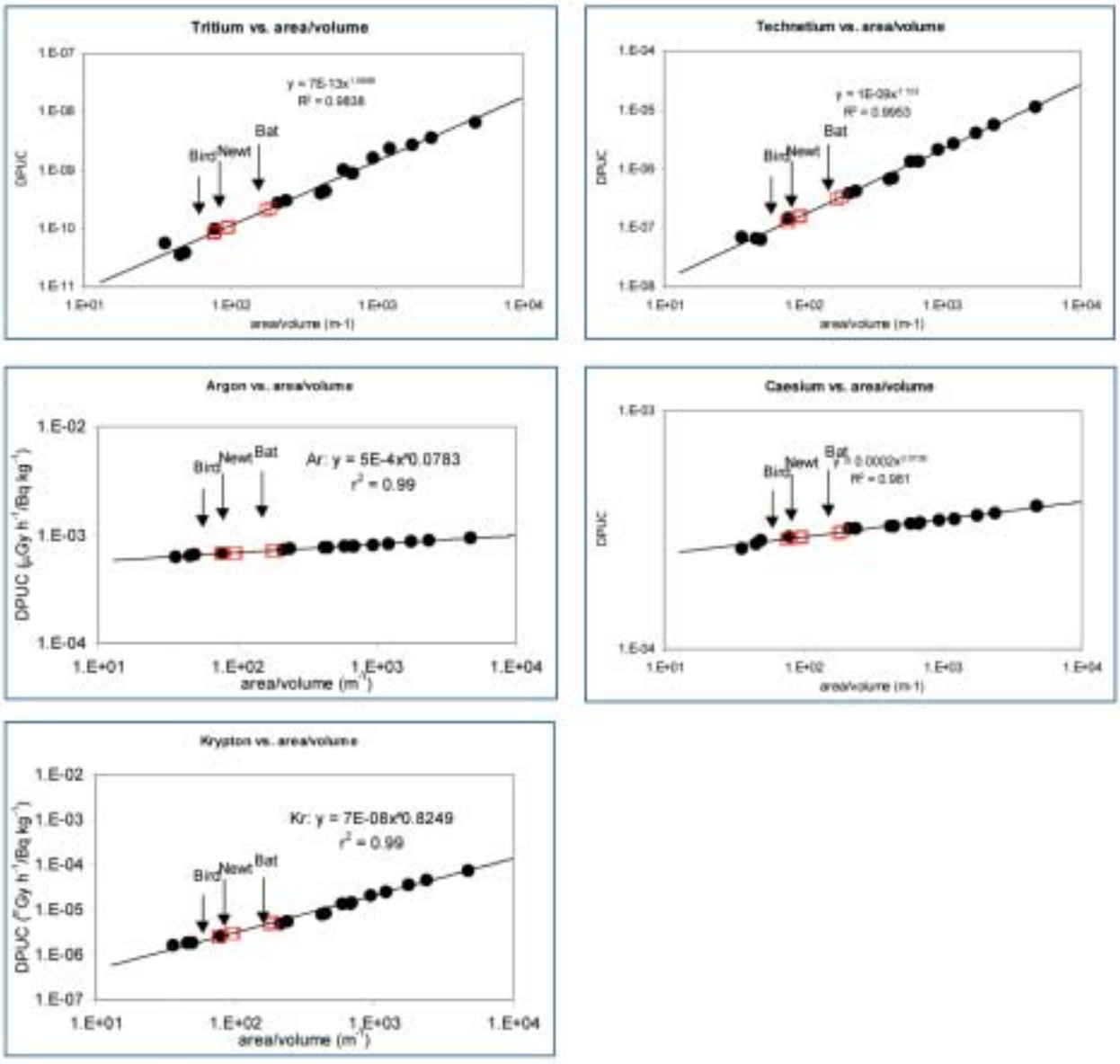
- For low β internal irradiation, DPUCs tend to correlate linearly with area/volume (mean linear r^2 for 15 radionuclides = 0.982 ± 0.004 compared with mean log-log r^2 of 0.715 ± 0.008). All nuclides have $r^2 > 0.95$. For low β external irradiation both linear and log-log fittings are of similar quality (mean r^2 for 17 radionuclides = 0.9 ± 0.3, only two nuclides with $r^2 < 0.95$).
- For $\beta + \gamma$ internal irradiation a power relationship tends to yield good results (mean r^2 = 0.87 ± 0.11 vs. 0.64 ± 0.24 for linear), with only a handful of radionuclides (five out of 28) yielding $r^2 < 0.8$. For external irradiation power functions also fit the data for most radionuclides (mean r^2 = 0.91 ± 0.09 vs. 0.64 ± 0.24 for linear) with only six out of 28 radionuclides yielding $r^2 < 0.8$.
- For α irradiation it is not possible to calculate trends because for internal irradiation the α DPUC is independent of organism size, and for external irradiation α component is zero.
- Total DPUCs for internal irradiation seem to follow a decreasing log-log function with area/volume (mean r^2 = 0.85 ± 0.12 vs. 0.66 ± 0.25 for linear, only seven nuclides with $r^2 < 0.8$). Conversely, total DPUC's for external irradiation follow an increasing function log-log (mean r^2 = 0.91 ± 0.09 vs. 0.66 ± 0.25 for linear, only six nuclides with $r^2 < 0.8$).
- Although the intercepts of the log-log functions vary greatly with each different radionuclide, the slope of the function is relatively constant (within an order of magnitude) in respect of radionuclide, enabling calculation of a mean value of -0.21 ± 0.26 for internal irradiation and 0.37 ± 0.40 for external irradiation.

For aquatic organisms, similar conclusions are reached, although the correlation coefficients tend to

be lower than in the terrestrial case (a mean $r^2 = 0.67 \pm 0.11$ instead of 0.90 ± 0.05). This is due to the wider spread of area/volume ratios in aquatic organisms (7.7×10^0 - 1.2×10^7 m^{-1} for aquatic versus 3.6×10^1 - 4.8×10^3 m^{-1} for terrestrial) with the inherent difficulty associated with interpolating over the wider range. Removing from the aquatic analysis the organisms with an extreme value of the surface/area ratio (eg bacteria and phytoplankton) changes the average correlation coefficient to 0.86 ± 0.07, nearly as high as estimated for terrestrial organisms. It does therefore follow that the conclusions for terrestrial organisms are also applicable to aquatic organisms - with the possible exception of bacteria and, to a lesser degree, phytoplankton, whose values of area/volume are difficult to estimate accurately due to their small dimensions.

An example of the above conclusions is given by the total DPUCs arising from external irradiation of ^{3}H, ^{41}Ar, ^{85}Kr, ^{99}Tc and ^{137}Cs (Table 4.4). Full details are provided in Appendix 5. From this table, it can be seen that a log-log linear function provides the best fit and correlation coefficients are quite satisfactory, including argon and krypton. Additional geometries for Crested newt, bird (average of 44 species) and Greater horseshoe bat are included to show how DPUCs for these organisms are calculable using the log-log power function deduced from the R&D Publication 128 dataset once area/volume ratio values are known.

Figure 4.1 Plots of a number of radionuclides (^{3}H, ^{99}Tc, ^{137}Cs, ^{41}Ar and ^{85}Kr) as examples of the observed relationship between organism area/volume ratio and the DPUC values.



Inputting the area/volume ratio, for an organism of dimensions different from those R&D Publication 128 ellipsoids, in the above mathematical relationships, appears to result in a reasonable approximation for the new DPUCs for most radionuclides. For this reason, one should not always need, in principle, to recalculate the complex Monte Carlo absorbed fraction iterations to produce DPUCs for organisms of dimensions different to those initially specified. It should be sufficient to find the nearest R&D Publication 128 reference organism in terms of area per volume, either above or below, and assign this organismís DPUC to the new organism. Supporting evidence demonstrating the appropriateness of selecting a substitute organism in terms of the area/volume ratio is given in Appendix 5.

Table 4.4 Linear and power best-square fittings for total DPUC (external) *versus* area/volume ratio, for ^{3}H, ^{41}Ar, ^{85}Kr, ^{99}Tc and ^{137}Cs. Values for newt, bird and bat (in Italics) are interpolated using the log-log relationships.

Organism	Area/ volume ratio (m^{-1})	Total DPUC (external), $\mu Gy\ h^{-1}/Bq\ kg^{-1}$				
		^{3}H	^{41}Ar	^{85}Kr	^{99}Tc	^{137}Cs
Lichen	9.4E+02	1.6E-09	8.1E-04	2.1E-05	2.2E-06	3.5E-04
Moss	5.9E+02	1.0E-09	7.8E-04	1.4E-05	1.4E-06	3.4E-04
Tree	2.4E+03	3.6E-09	8.8E-04	4.6E-05	5.6E-06	3.7E-04
Shrub	2.4E+03	3.6E-09	8.8E-04	4.6E-05	5.6E-06	3.7E-04
Grass	2.4E+03	3.6E-09	8.8E-04	4.6E-05	5.6E-06	3.7E-04
Germinating seed	4.8E+03	6.5E-09	9.4E-04	7.6E-05	1.1E-05	4.0E-04
Fungal fruiting body	4.2E+02	4.0E-10	7.6E-04	7.9E-06	6.7E-07	3.3E-04
Caterpillar	6.9E+02	8.9E-10	7.9E-04	1.4E-05	1.4E-06	3.4E-04
Ant	1.8E+03	2.8E-09	8.6E-04	3.6E-05	4.2E-06	3.6E-04
Bee	4.4E+02	4.4E-10	7.6E-04	8.4E-06	7.2E-07	3.3E-04
Wood louse	1.2E+03	2.3E-09	8.2E-04	2.4E-05	2.8E-06	3.5E-04
Earthworm	6.7E+02	8.8E-10	7.9E-04	1.4E-05	1.3E-06	3.4E-04
Herbivorous mammal	4.5E+01	3.5E-11	6.4E-04	1.8E-06	6.6E-08	2.8E-04
Carnivorous mammal	3.6E+01	5.7E-11	6.2E-04	1.7E-06	6.8E-08	2.6E-04
Small burrowing rodent	2.4E+02	3.0E-10	7.4E-04	5.4E-06	4.3E-07	3.2E-04
Woodland bird	4.9E+01	3.9E-11	6.7E-04	1.8E-06	6.4E-08	2.9E-04
Bird egg	2.1E+02	2.7E-10	7.4E-04	4.9E-06	3.8E-07	3.2E-04
Reptile	7.9E+01	9.7E-11	6.8E-04	2.6E-06	1.4E-07	3.0E-04
Crested newt (male)	9.4E+01	1.0E-10	6.8E-04	2.9E-06	1.6E-07	3.0E-04
Crested newt (female)	9.8E+01	1.1E-10	6.8E-04	3.0E-06	1.6E-07	3.0E-04
Male bird average	7.7E+01	8.4E-11	6.7E-04	2.5E-06	1.2E-07	2.9E-04
Female bird average	7.8E+01	8.5E-11	6.7E-04	2.5E-06	1.3E-07	2.9E-04
Greater horseshoe bat (female)	1.8E+02	2.1E-10	7.2E-04	4.9E-06	3.1E-07	3.1E-04
Greater horseshoe bat (male)	1.9E+02	2.2E-10	7.2E-04	5.2E-06	3.3E-07	3.1E-04
Linear slope		1.4E-12	6.4E-08	1.7E-08	2.4E-09	2.5E-08
Linear intercept		3.7E-11	7.1E-04	2.6E-06	-1.3E-07	3.1E-04
Linear r^2		9.9E-01	7.6E-01	9.8E-01	1.0E+00	7.2E-01
Log-Log slope		1.1E+00	7.8E-02	8.2E-01	1.1E+00	7.4E-02
Log-Log intercept		-2.8E+01	-7.6E+00	-1.6E+01	-2.1E+01	-8.5E+00
Log-Log r^2		9.8E-01	9.9E-01	9.9E-01	1.0E+00	9.8E-01

A substantial number of additional organism geometries for the species identified by the review in Section 4.1 have been treated as above. Table 4.5 has been construced from a table found in Appendix 5. In this table, data for the feature organism geometries are represented in bold italics and the R&D Publication 128 geometries in base font. R<= and R=> are the quotients between the area/volume ratio for the reference organisms from R&D Publication 128 appearing immediately before or after to the feature organism geometry in the vertical ordering given in Table 4.5, and the area/volume ratio for the aforesaid feature organism geometry. In this context, 1 - R<= and 1 - R=> are, quite simply, the incremental differences between the area/volume of the closest previous (R<=) or next (R=>) R&D128 reference organisms and that of the feature organism, normalised to the area/volume of the feature organism. Which of these fractional differences is a smallest dictate whether the "previous" or "next" organism should be chosen as the nearest substitute for the feature organism geometry. For example, in the coastal aquatic ecosystem, the otter (male) has a fractional difference of 0.48 with respect to the seal and a 0.60 fractional difference with respect to the seabird reference organisms. Clearly, in this case, the seal should be the nearest geometry analogue. Conversely, the otter (female) has a fractional difference of 0.52 with respect to the seal reference organism and a 0.45 fractional difference with respect to the seabird. In this case it should be the seabird, rather than the seal, that should be chosen as the nearest geometry analogue.

This process has enabled the justification for the selection of particular R&D Publication 128 reference organisms in terms of the pre-existing geometries of R&D Publication 128 by means of a practical and reproducible method. Because the correlation coefficients for the log-log fittings between DPUC and area/volume appear similarly high for both internal and external irradiation, confidence is generated that selecting an R&D 128 reference organism to represent a feature species is a workable method for estimating both internal and external DPUCs.

It has been mentioned before that the slope of the log-log curves for different radionuclides is sufficiently uniform to enable calculation of a mean value. This permitted the calculation of an approximate indication of the amount of deviation (δDPUC) arising from a deviation in area/volume in respect of any reference organism of R&D Publication 128, according to the formula: δDPUC = DPUC δ log-log intercept *x* (1 -R<=>), where R<=> is the next or previous reference organism in the list in Table 4.5. Table 4.5 contains such an intuitive estimation of error, providing a practical way to deduce approximately what error is committed when representing a feature organism in terms of the nearest R&D Publication 128 organism using the of area/volume ratio as the organism classification criteria.

Dimensions for plants are not conducive to a proper representation by means of an ellipsoid. Hence, additional plant geometries are not treated in Tables 4.5 and 4.6. One should use the macrophyte, shrub or herb categories of R&D Publication 128 to represent feature plants, whichever is more appropriate.

From Table 4.5, it is possible to identify the nearest R&D Publication 128 geometric shape to the feature species, eg use seal for otter (male) and bird egg for greater horseshoe bat. However, the best analogues in terms of both geometry and biology (CFs and occupancy factors) do not always coincide, although there are no organisms in which there is an ecosystem mismatch in respect of the substitute geometry. In other words, a nearest geometry for each feature organism is provided for all the ecosystems of interest in which such organism can exist. This option ensures that an assessment can always be performed using the assessment spreadsheet relating to the ecosystem to which a feature organism belongs.

Table 4.5 Justification and error estimation for the feature species with pre-existing geometries of R&D Publication 128 (new organisms in bold italics).

Reference organism	Ecosystem	Area/ volume ratio (m^{-1})	% Error	
			Internal	External
Whale	Coastal aquatic	7.7	0.0	0.0
Grey seal	***Coastal aquatic***	***12.2***	***6.6***	***14.5***
Common seal	***Coastal aquatic***	***14.8***	***5.3***	***11.8***
Pink-footed goose	***Coastal aquatic***	***16.2***	***3.4***	***7.6***
Seal	Coastal aquatic	19.3	0.0	0.0
Cormorant	***Coastal aquatic***	***19.4***	***0.0***	***0.1***
Bittern	***Coastal aquatic***	***20.4***	***0.9***	***2.1***
Scaup	***Coastal aquatic***	***29.3***	***6.0***	***13.3***
Whooper swan	***Coastal aquatic***	***31.5***	***6.8***	***15.1***
Chough	***Coastal aquatic***	***33.9***	***7.6***	***16.8***
Bewicks swan	***Coastal aquatic***	***34.0***	***7.6***	***16.9***
Otter (male)	***Coastal aquatic***	***36.8***	***8.4***	***18.6***
Lapwing	***Coastal aquatic***	***38.2***	***8.7***	***19.3***
Otter (female)	***Coastal aquatic***	***40.7***	***8.0***	***17.7***
Grey plover	***Coastal aquatic***	***41.1***	***7.7***	***17.1***
Atlantic salmon	***Coastal aquatic***	***41.1***	***7.7***	***17.1***
Knot	***Coastal aquatic***	***43.5***	***6.3***	***13.9***
Golden plover	***Coastal aquatic***	***44.4***	***5.8***	***12.9***
Common tern	***Coastal aquatic***	***45.0***	***5.5***	***12.3***
Snipe	***Coastal aquatic***	***46.6***	***4.7***	***10.4***
Ruff	***Coastal aquatic***	***46.9***	***4.6***	***10.2***
White-fronted goose	***Coastal aquatic***	***47.9***	***4.1***	***9.1***
Allis shad	***Coastal aquatic***	***51.4***	***2.6***	***5.9***
Peregrine falcon	***Coastal aquatic***	***52.6***	***2.2***	***4.8***
Gannet	***Coastal aquatic***	***53.6***	***1.8***	***4.0***
Dunlin	***Coastal aquatic***	***58.0***	***0.3***	***0.7***
Seabird	Coastal aquatic	59.1	0.0	0.0
Little tern	***Coastal aquatic***	***61.1***	***0.6***	***1.3***
Shelduck (male)	***Coastal aquatic***	***63.8***	***1.3***	***2.9***
Sanderling	***Coastal aquatic***	***64.6***	***1.5***	***3.3***
Common scoter	***Coastal aquatic***	***64.6***	***1.5***	***3.4***
Twaite shad	***Coastal aquatic***	***65.8***	***1.8***	***4.0***
Tufted duck (male)	***Coastal aquatic***	***66.6***	***2.0***	***4.4***
Sea lamprey	***Coastal aquatic***	***66.6***	***2.0***	***4.4***
Brent goose	***Coastal aquatic***	***68.4***	***1.9***	***4.3***
Wigeon	***Coastal aquatic***	***69.5***	***1.6***	***3.6***
Tufted duck (female)	***Coastal aquatic***	***69.8***	***1.5***	***3.4***
Shelduck (female)	***Coastal aquatic***	***70.4***	***1.4***	***3.1***
Curlew	***Coastal aquatic***	***71.1***	***1.2***	***2.7***
Gadwall	***Coastal aquatic***	***71.7***	***1.1***	***2.3***
Great crested grebe	***Coastal aquatic***	***72.5***	***0.8***	1.8
Pelagic fish	Coastal aquatic	75.9	0.0	0.0
Benthic fish	Coastal aquatic	75.9	0.0	0.0
Guillemot	***Coastal aquatic***	***76.4***	***0.1***	***0.2***
Kittewake	***Coastal aquatic***	***76.5***	***0.1***	***0.3***
Razorbill	***Coastal aquatic***	***76.5***	***0.1***	***0.3***
Manx shearwater	***Coastal aquatic***	***76.7***	***0.2***	***0.4***
Puffin	***Coastal aquatic***	***78.4***	***0.6***	***1.2***

Table 4.5 | Continued

Reference organism	Ecosystem	Area/ volume ratio (m^{-1})	% Error	
			Internal	External
Pintail	*Coastal aquatic*	*81.3*	*1.2*	*2.6*
Marsh harrier	*Coastal aquatic*	*85.7*	*2.0*	*4.4*
Oystercatcher	*Coastal aquatic*	*86.5*	*2.2*	*4.8*
Lesser black-backed gull	*Coastal aquatic*	*94.7*	*3.5*	*7.8*
Teal	*Coastal aquatic*	*98.2*	*4.0*	*8.8*
Hen harrier (male and female)	*Coastal aquatic*	*100.9*	*4.4*	*9.7*
Black-tailed godwit	*Coastal aquatic*	*117.6*	*6.3*	*13.8*
Bar-tailed godwit	*Coastal aquatic*	*117.8*	*6.3*	*13.9*
Avocet	*Coastal aquatic*	*123.2*	*6.8*	*15.0*
Mediterranean gull	*Coastal aquatic*	*124.1*	*6.9*	*15.2*
Sandwich tern	*Coastal aquatic*	*125.9*	*7.0*	*15.5*
StormpPetrel	*Coastal aquatic*	*143.6*	*8.3*	*18.4*
Turnstone	*Coastal aquatic*	*144.9*	*8.4*	*18.6*
Redshank	*Coastal aquatic*	*149.5*	*8.7*	*19.2*
Ringed plover	*Coastal aquatic*	*162.5*	*9.4*	*20.8*
River lamprey	*Coastal aquatic*	*210.0*	*11.3*	*24.9*
Large benthic crustacean	Coastal aquatic	474.4	0.0	0.0
Benthic mollusc	Coastal aquatic	605.6	0.0	0.0
Small benthic crustacean	Coastal aquatic	2354.3	0.0	0.0
Zooplankton	Coastal aquatic	2354.3	0.0	0.0
Macrophyte	Coastal aquatic	2356.7	0.0	0.0
Fish egg	Coastal aquatic	3000.0	0.0	0.0
Phytoplankton	Coastal aquatic	120000.0	0.0	0.0
Bacteria	Coastal aquatic	12000000.0	0.0	0.0
Pink-footed goose	*Freshwater*	*16.2*	*46.7*	*103.4*
Cormorant	*Freshwater*	*19.4*	*36.2*	*80.1*
Bittern	*Freshwater*	*20.4*	*33.4*	*74.0*
Scaup	*Freshwater*	*29.3*	*17.9*	*39.6*
Whooper swan	*Freshwater*	*31.5*	*15.5*	*34.2*
Bewicks swan	*Freshwater*	*34.0*	*13.0*	*28.8*
Otter (male and female)	*Freshwater*	*36.8*	*10.6*	*23.6*
Brook lamprey	*Freshwater*	*37.7*	*10.0*	*22.2*
Lapwing	*Freshwater*	*38.2*	*9.6*	*21.3*
Grey plover	*Freshwater*	*41.1*	*7.7*	*17.1*
Atlantic salmon	*Freshwater*	*41.1*	*7.7*	*17.1*
Knot	*Freshwater*	*43.5*	*6.3*	*13.9*
Golden plover	*Freshwater*	*44.4*	*5.8*	*12.9*
Snipe	*Freshwater*	*46.6*	*4.7*	*10.4*
Ruff	*Freshwater*	*46.9*	*4.6*	*10.2*
White-fronted goose	*Freshwater*	*47.9*	*4.1*	*9.1*
Allis shad	*Freshwater*	*51.4*	*2.6*	*5.9*
Dunlin	*Freshwater*	*58.0*	*0.3*	*0.7*
Duck	Freshwater	59.1	0.0	0.0
Shelduck (male)	*Freshwater*	*63.8*	*1.3*	*2.9*
Sanderling	*Freshwater*	*64.6*	*1.5*	*3.3*
Common scoter	*Freshwater*	*64.6*	*1.5*	*3.4*
Twaite shad	*Freshwater*	*65.8*	*1.8*	*4.0*
Tufted duck (male)	*Freshwater*	*66.6*	*2.0*	*4.4*

Table 4.5 | Continued

Reference organism	Ecosystem	Area/ volume ratio (m^{-1})	% Error	
			Internal	External
Sea lamprey	*Freshwater*	*66.6*	*2.0*	*4.4*
Brent goose	*Freshwater*	*68.4*	*1.9*	*4.3*
Wigeon	*Freshwater*	*69.5*	*1.6*	*3.6*
Tufted duck (female)	*Freshwater*	*69.8*	*1.5*	*3.4*
Shelduck (female)	*Freshwater*	*70.4*	*1.4*	*3.1*
Curlew	*Freshwater*	*71.1*	*1.2*	*2.7*
Gadwall	*Freshwater*	*71.7*	*1.1*	*2.3*
Great crested grebe	*Freshwater*	*72.5*	*0.8*	*1.8*
Shoveler	*Freshwater*	*73.3*	*0.6*	*1.4*
Pelagic fish	Freshwater	75.9	0.0	0.0
Benthic fish	Freshwater	75.9	0.0	0.0
Pintail	*Freshwater*	*81.3*	*1.2*	*2.6*
Hen harrier (female)	*Freshwater*	*84.8*	*1.8*	*4.1*
Marsh harrier	*Freshwater*	*85.7*	*2.0*	*4.4*
Oystercatcher	*Freshwater*	*86.5*	*2.2*	*4.8*
Lesser black-backed gull (male)	*Freshwater*	*87.8*	*2.4*	*5.3*
Teal (male)	*Freshwater*	*91.1*	*2.9*	*6.5*
Great crested newt	*Freshwater*	*93.8*	*2.5*	*5.4*
Lesser black-backed gull (female)	*Freshwater*	*94.7*	*2.3*	*5.0*
Teal (female)	*Freshwater*	*98.2*	*1.6*	*3.5*
Hen harrier (male)	*Freshwater*	*100.9*	*1.0*	*2.3*
Amphibian	Freshwater	106.8	0.0	0.0
Natterjack toad	*Freshwater*	*107.5*	*0.1*	*0.2*
Black-tailed godwit	*Freshwater*	*117.6*	*1.6*	*3.6*
Bar-tailed godwit	*Freshwater*	*117.8*	*1.6*	*3.7*
Avocet	*Freshwater*	*123.2*	*2.3*	*5.2*
Mediterranean gull	*Freshwater*	*124.1*	*2.5*	*5.4*
Turnstone	*Freshwater*	*144.9*	*4.6*	*10.3*
Redshank	*Freshwater*	*149.5*	*5.0*	*11.2*
Spined loach	*Freshwater*	*154.6*	*5.5*	*12.1*
Ringed plover	*Freshwater*	*162.5*	*6.0*	*13.4*
Bullhead	*Freshwater*	*170.5*	*6.6*	*14.6*
River lamprey	*Freshwater*	*210.0*	*2.5*	*5.5*
Small aquatic mammal	Freshwater	239.7	0.0	0.0
Large benthic crustacean	Freshwater	474.4	0.0	0.0
Benthic mollusc	Freshwater	605.6	0.0	0.0
Desmoulins whorl snail	*Freshwater*	*688.5*	*2.1*	*4.7*
Southern damselfly	*Freshwater*	*1270.8*	*9.2*	*20.5*
Small benthic crustacean	Freshwater	2354.3	0.0	0.0
Zooplankton	Freshwater	2354.3	0.0	0.0
Macrophyte	Freshwater	2356.7	0.0	0.0
Early gentian	*Freshwater*	*2356.7*	*0.0*	*0.0*
Fen orchid	*Freshwater*	*2356.7*	*0.0*	*0.0*
Phytoplankton	Freshwater	120000.0	0.0	0.0
Bacteria	Coastal aquatic	12000000.0	0.0	0.0
Pink-footed goose	*Terrestrial*	*16.2*	*21.6*	*47.8*
Whooper swan	*Terrestrial*	*31.5*	*2.5*	*5.6*
Chough	*Terrestrial*	*33.9*	1.1	2.4

Table 4.5 | Continued

Reference organism	Ecosystem	Area/ volume ratio (m^{-1})	% Error	
			Internal	External
Bewicks swan	*Terrestrial*	*34.0*	*1.0*	*2.3*
Carnivorous mammal	Terrestrial	36.0	0.0	0.0
Lapwing	*Terrestrial*	*38.2*	*1.0*	*2.3*
Otter	*Terrestrial*	*40.7*	*2.0*	*4.5*
GreypPlover	*Terrestrial*	*41.1*	*1.9*	*4.1*
Short-eared owl	*Terrestrial*	*41.6*	*1.6*	*3.6*
Knot	*Terrestrial*	*43.5*	*0.8*	*1.7*
Golden plover	*Terrestrial*	*44.4*	*0.4*	*0.9*
Herbivorous mammal	Terrestrial	45.4	0.0	0.0
Snipe	*Terrestrial*	*46.6*	*0.5*	*1.0*
Ruff	*Terrestrial*	*46.9*	*0.6*	*1.2*
White-fronted goose	*Terrestrial*	*47.9*	*0.5*	*1.0*
Bird	Terrestrial	49.2	0.0	0.0
Peregrine falcon	*Terrestrial*	*52.6*	*1.1*	*2.5*
Dunlin	*Terrestrial*	*58.0*	*2.7*	*5.9*
Sanderling	*Terrestrial*	*64.6*	*3.8*	*8.5*
Brent goose	*Terrestrial*	*68.4*	*2.6*	*5.8*
Wigeon	*Terrestrial*	*69.5*	*2.3*	*5.1*
Curlew	*Terrestrial*	*71.1*	*1.9*	*4.2*
Gadwall	*Terrestrial*	*71.7*	*1.7*	*3.8*
Pintail	*Terrestrial*	*71.9*	*1.7*	*3.7*
Honey buzzard	*Terrestrial*	*72.5*	*1.5*	*3.3*
Shoveler	*Terrestrial*	*73.3*	*1.3*	*2.8*
Kittewake	*Terrestrial*	*76.5*	*0.5*	*1.1*
Reptile	Terrestrial	78.6	0.0	0.0
Smooth snake	*Terrestrial*	*78.9*	*0.0*	*0.1*
Marsh harrier	*Terrestrial*	*85.7*	*1.4*	*3.2*
Stone curlew	*Terrestrial*	*86.5*	*1.6*	*3.5*
Oystercatcher	*Terrestrial*	*86.5*	*1.6*	*3.6*
Lesser black-backed gull	*Terrestrial*	*94.7*	*3.0*	*6.6*
Great crested newt	*Terrestrial*	*97.5*	*3.4*	*7.6*
Teal	*Terrestrial*	*98.2*	*3.5*	*7.8*
Dartford warbler	*Terrestrial*	*99.4*	*3.7*	*8.2*
Hen harrier (male and female)	*Terrestrial*	*100.9*	*3.9*	*8.6*
Woodlark	*Terrestrial*	*101.3*	*3.9*	*8.7*
Natterjack toad	*Terrestrial*	*107.5*	*4.7*	*10.5*
Black-tailed godwit	*Terrestrial*	*117.6*	*5.8*	*12.9*
Mediterranean gull	*Terrestrial*	*124.1*	*6.5*	*14.3*
Sand lizard	*Terrestrial*	*127.8*	*6.8*	*15.0*
Redshank	*Terrestrial*	*149.5*	*7.5*	*16.5*
Nightjar	*Terrestrial*	*154.8*	*6.6*	*14.6*
Bechsteins bat	*Terrestrial*	*156.5*	*6.3*	*14.0*
Ringed plover	*Terrestrial*	*162.5*	*5.5*	*12.1*
Dormouse	*Terrestrial*	*165.5*	*5.0*	*11.1*
Greater horseshoe bat	*Terrestrial*	*176.4*	*3.6*	*8.0*
Lesser horseshoe bat	*Terrestrial*	*184.3*	*2.7*	*6.0*
Bird egg	Terrestrial	212.7	0.0	0.0
Rodent	Terrestrial	239.7	0.0	0.0

Table 4.5 | Continued

Reference organism	Ecosystem	Area/ volume ratio (m^{-1})	% Error	
			Internal	External
Stag beetle	***Terrestrial***	***290.6***	***3.1***	***6.8***
Fungi	Terrestrial	418.0	0.0	0.0
Bee	Terrestrial	443.1	0.0	0.0
Earthworm	Terrestrial	674.5	0.0	0.0
Caterpillar	Terrestrial	688.5	0.0	0.0
Desmoulins whorl snail	***Terrestrial***	***688.5***	***0.0***	***0.0***
Lichen	Terrestrial	943.6	0.0	0.0
Woodlouse	Terrestrial	1220.4	0.0	0.0
Ant	Terrestrial	1759.1	0.0	0.0
Herb	Terrestrial	2356.7	0.0	0.0
Early gentian	***Terrestrial***	***2356.7***	***0.0***	***0.0***
Fen orchid	***Terrestrial***	***2356.7***	***0.0***	***0.0***
Petal wort	***Terrestrial***	***2356.7***	***0.0***	***0.0***
Shore dock	***Terrestrial***	***2356.7***	***0.0***	***0.0***
Shrub	Terrestrial	2356.7	0.0	0.0
Tree	Terrestrial	2356.7	0.0	0.0
Seed	Terrestrial	4769.8	0.0	0.0
Bacteria	Terrestrial	12000000.0	0.0	0.0

For example, the Bewicks swanís geometry can be listed against a seal, duck or carnivorous mammal in the coastal aquatic, freshwater and terrestrial ecosystems, respectively. Let us suppose a situation in which one is assessing the dose rate to a Bewicks swan in the coastal aquatic context. To carry out this assessment using the correct geometry, one would have to employ the R&D Publication 128 coastal aquatic spreadsheet using the seal geometry, but in terms of biological uptake/concentration factors, the swan is best represented by a seabird. Hence the CFs and occupancy factors in the "seal" column of this spreadsheet would have to be changed, using the "seabird" values instead of the "seal" values in that column. To assess the dose rate to a Bewicks swan in the terrestrial context, one would have to employ the R&D Publication 128 terrestrial spreadsheet using the carnivorous mammal geometry, entering manually under the "carnivorous mammal" column the CF and occupancy factor values for ìbirdî. In this way, the best physical analogue (hence the most suitable DPUC factors) and the best biological analogue (hence the most suitable CFs and occupancy factors) would be selected using the correct ecosystem assessment spreadsheet.

In Table 4.6, 72 marine, 69 freshwater and 69 terrestrial organisms identified as feature species have been assigned an equivalent geometry in terms of R&D Publication 128.

It must be emphasised that, ideally, absorbed fractions and doses for all new geometries should be calculated using the Monte Carlo absorbed fraction functional method. As these calculations are onerous, and outside the remit of this project, it is reasonable to work out approximations as described above. In future, an improved set of organism dimensions for these new organisms could be produced to further help assessors.

An examination of Table 4.5 then reveals that the Bewicks swan (area/volume = 34 m^{-1}) can still be approximated in an acceptable way by the seal geometry (area/volume = 19 m^{-1}) or the seabird geometry (area/volume = 59 m^{-1}), with area/volume fractional differences of 0.43 and 0.74 respectively. Choosing the seal geometry would result in a likely error of just 7.6% for the external dose and 16.9% for the internal dose. It has been concluded that the errors in dosimetry factors estimated by adopting a substitute geometry are generally small, not exceeding 20% for internal doses and 50% for external doses in 99% of cases, and being on average in the order of 3.5% and 7.5% respectively.

4.4 Literature to identify occupancy factors for use in the Stage 3 Assessment

Radionuclides released into an ecosystem will have different environmental fates depending on factors such as their origin, physico-chemical properties and bioavailability. The resulting ecosystem compartment into which they become incorporated will determine the range of organisms exposed to these radionuclides. Therefore, when calculating the dose rates to organisms in each of the three R&D Publication 128 spreadsheets (terrestrial, coastal and freshwater), it is necessary to understand the residence time of each organism in each ecosystem compartment.

Table 4.6 Equivalence between feature species and reference geometries of R&D Publication 128, with attention paid to the ecosystem represented by the different dose assessment spreadsheets

Ecosystem	Species	Equivalent geometry (R&D Publication 128)
Coastal	Avocet, Bar-tailed godwit, Black-tailed godwit, Brent goose, Curlew, Gadwall, Great crested grebe, Guillemot, Hen harrier (male and female), Kittewake, Lesser Black-backed gull (male and female), Manx shearwater, Marsh harrier, Mediterranean gull, Oystercatcher, Pintail, Puffin, Razorbill, Redshank, Ringed plover, River lamprey, Sandwich tern, Shelduck (female), Storm petrel, Teal, Tufted duck (female), Turnstone, Wigeon	Benthic fish
	Allis shad, Atlantic salmon, Common scoter, Common tern, Dunlin, Gannet, Golden plover, Grey plover, Knot, Little tern, Otter (female), Peregrine falcon, Ruff, Sanderling, Sea lamprey, Shelduck (male), Snipe, Tufted duck (male), Twaite shad, White-fronted goose	Seabird
	Bewicks swan, Bittern, Chough, Common seal, Cormorant, Lapwing, Otter (male), Pink-footed goose, Scaup, Whooper swan	Seal
	Grey seal	Whale
Freshwater	Avocet, Bar-tailed godwit, Black-tailed godwit, Bullhead, Great crested newt, Hen harrier (male), Lesser black-backed gull (female), Mediterranean gull, Natterjack toad, Redshank, Ringed plover, Spined loach, Teal (female), Turnstone	Amphibian
	Brent goose, Curlew, Gadwall, Great crested grebe, Hen harrier (female), Lesser black-backed gull (male), Marsh harrier, Oystercatcher, Pintail, Shelduck (female), Shoveler, Teal (male), Tufted duck (female), Wigeon	Benthic fish
	Desmoulins whorl snail, Southern damselfly	Benthic mollusc
	Allis shad, Atlantic salmon, Bewicks swan, Bittern, Brook lamprey, Common scoter, Cormorant, Dunlin, Golden plover, Grey plover, Knot, Lapwing, Otter (male and female), Pink-footed goose, Ruff, Sanderling, Scaup, Sea lamprey, Shelduck (male), Snipe, Tufted duck (male), Twaite shad, White-fronted goose, Whooper swan	Duck
	Early gentian, Fen orchid	Macrophyte
	River lamprey	Small aquatic mammal

Table 4.6 | Continued

Ecosystem	Species	Equivalent geometry (R&D Publication 128)
Terrestrial	Dunlin, Peregrine falcon, White-fronted goose	Bird
	Bechsteins bat, Dormouse, Greater horseshoe bat, Lesser horseshoe bat, Nightjar, Redshank, Ringed plover	Bird egg
	Bewicks swan, Chough, Lapwing, Otter, Pink-footed goose, Whooper swan	Carnivorous mammal
	Desmoulins whorl snail	Caterpillar
	Early gentian, Fen orchid, Petal wort, Shore dock	Herb
	Golden plover, Grey plover, Knot, Ruff, Short-eared owl, Snipe	Herbivorous mammal
	Black-tailed godwit, Brent goose, Curlew, Dartford warbler, Gadwall, Great crested newt, Hen harrier (male and female), Honey buzzard, Kittewake, Lesser black-backed gull (male and female), Marsh harrier, Mediterranean gull, Natterjack toad, Oystercatcher, Pintail, Sand lizard, Sanderling, Shoveler, Smooth snake, Stone curlew, Teal, Wigeon, Woodlark	Reptile
	Stag beetle	Rodent

For example, a terrestrial ecosystem can be viewed as having three principal components: the soil, the soil surface and the air. When considering the radiation exposure of a bird in a terrestrial ecosystem, there will be a period of time during which the bird is resident on the soil surface and a period of time that it spends in the air.

The time that an organism spends in each compartment of the ecosystem is defined by its occupancy factor:

> *A measure of the time period that a specified organism spends in an identified ecosystem compartment of a named ecosystem as a fraction of the total time period that the organism spends in that ecosystem.*

Based on the definition given above, the sum of occupancy factors for any organism in any ecosystem should equal 1, ie. 100%. However, this is not always the case. For example, a seabird may have an occupancy factor of 0.7 for sediment and 0.1 for water resulting in an apparent occupancy within the coastal ecosystem of 0.8, which is <1. This is because the seabird has an occupancy factor of 0.2 in the air, but assessment of the dose while the bird is in the air is excluded from the coastal ecosystem spreadsheet. To understand the reasoning behind this, it is necessary to understand the application of the three spreadsheets from R&D Publication 128.

The spreadsheets are designed to model three (generic) ecosystem types and assumptions are made regarding the mode of radionuclide release into these ecosystems. For aquatic ecosystems (freshwater and coastal spreadsheets), it is assumed that the release of radionuclides is via discharge into a water body. Following discharge into a water body, the radionuclides may either remain in the aqueous phase or become associated with sediments depending on the partition coefficient (K_d) of the radionuclides released. Therefore, the contaminated media in an aquatic ecosystem are the water and the sediment. Note that in the coastal ecosystem, it is assumed that the area is continuously submerged or tidally inundated.

In a terrestrial ecosystem, it is assumed that the air is the primary receiving medium. Aerial deposition (both dry and wet) will result in the contamination of the soil surface and, depending on the environmental mobility of each radionuclide, leaching/mass transport will distribute these aerially deposited radionuclides through the soil profile. The contaminated media considered in the terrestrial environment are therefore the air, soil surface and soil.

The scenarios used in the spreadsheets are based on the radionuclide concentrations in contaminated medium or media in each ecosystem type. For this reason, occupancy factors are identified for the ecosystem compartments associated with these principal media only. Certain organisms may spend

time in an ecosystem compartment that is not associated with the principal medium/media in that ecosystem.

Another instance in which the occupancy factor may not equal 1 is when considering the dose rates to plants and fungi. The most highly exposed part of the plant/fungus, in terms of radiation exposure, is the roots/mycelium, when soil is the principal reservoir for radionuclide contamination. Consequently the plant has been allocated an occupancy factor of 1 for soil. However, this does not account for the immersion in air of the parts of the plant or fungus growing above the ground. Although pessimistic, it has been agreed that the above ground parts should therefore also be allocated an occupancy factor (in this case a value of 0.5) for air to account for this additional exposure (Vives, 2003). This results in a total occupancy factor of 1.5. Whilst this appears odd, it is because the calculations in the dose assessment spreadsheets assume a 4 pi (ie total immersion) in air. In practice, the plants are actually not completely immersed in air and therefore putting a factor of 0.5 corrects this.

Occupancy factors were determined with reference to literature on the habits of the different species (for example, Corbet and Southern, 1977 for mammals and Wilson, 1988 for birds) and are presented in Table 4.7.

4.5 Derivation of concentration factors for use in the Stage 3 Assessment

The use of Concentration Factors (CFs) is explained fully in R&D Publication 128, and is defined as the:

> *Ratio of element or nuclide in the consumer (or specific tissue or organ etc.), to that in what is consumed, or to that in the environmental medium (Copplestone et al., 2001).*

Briefly, a CF relates the concentration of a radionuclide in an environmental medium (air, soil or water) to the concentration of that radionuclide in an organism within that environment. It is generally calculated from actual measurements of radionuclide concentrations in the environmental media and biota present within an ecosystem. Consequently, the CF takes account of the physicochemical and physiological properties that govern the partitioning of radionuclides between organisms and their environment and is represented as a single number.

Table 4.7 | Recommended occupancy factors determined for the feature species[1]

Coastal	Sediment	Sediment surface	Water
Allis shad, Atlantic salmon, Twaite shad	0	0.1	0.9
Chough, Dunlin, Gannet, Hen harrier, Marsh harrier, Peregrine falcon	0	0.2	0.5[2]
Bewicks swan, Common scoter, Common tern, Cormorant, Gadwall, Great crested grebe, Guillimot, Kittewake, Little tern, Mediterranean gull, Pintail, Puffin, Razorbill, Sandwich tern, Scaup, Shelduck, Teal, Tufted duck, Whooper swan, Wigeon	0	0.3	0.5
Common seal, Grey seal, Otter	0	0.5	0.5
Avocet, Bar-tailed godwit, Bittern, Black-tailed godwit, Brent goose, Curlew, Golden plover, Grey plover, Knot, Lapwing, Lesser black-backed gull, Manx shearwater, Oystercatcher, Pink-footed goose, Redshank, Ringed plover, Ruff, Sanderling, Snipe, Storm petrel, Turnstone, White-fronted goose	0	0.7	0.1
River lamprey, Sea lamprey	0	0.9	0.1

[1]Mainly based on the default values in R&D Publication 128

[2]Assumed to spend large amount of time in the air - spreadsheets won't accept this, so as a conservative measure assumed higher

Table 4.7 | Continued

Freshwater	Sediment	Sediment surface	Water
Allis shad, Atlantic salmon, Spined loach, Twaite shad	0	0.1	0.9
Desmoulins whorl snail, Dunlin, Hen harrier, Marsh harrier	0	0.2	0.5[1]
Bewicks swan, Bittern, Common scoter, Cormorant, Gadwall, Great crested grebe, Mediterranean gull, Pintail, Scaup, Shelduck, Shoveler, Teal, Tufted duck, Whooper swan, Wigeon	0	0.3	0.5
Otter	0	0.5	0.5
Avocet, Bar-tailed godwit, Black-tailed godwit, Brent Goose, Curlew, Golden plover, Grey plover, Knot, Lapwing, Lesser black-backed gull, Oystercatcher, Pink-footed goose, Redshank, Ringed plover, Ruff, Sanderling, Snipe, Turnstone, White-fronted goose	0	0.7	0.3
Southern damselfly	0	0.7	0.3
Brook lamprey, Bullhead, River lamprey, Sea lamprey	0	0.9	0.1
Great crested newt, Natterjack toad	0.1	0.6	0.3
Early gentian, Fen orchid[2]	1	0	0.5

Terrestrial	Sediment	Sediment surface	Water
Bechsteins bat, Greater horseshoe bat, Lesser horseshoe bat	0	0	1
Bewicks swan, Chough, Gadwall, Kittewake, Mediterranean gull, Pintail, Shoveler, Teal, Whooper swan, Wigeon	0	0.3	0.5
Dartford warbler, Desmoulins whorl snail, Dunlin, Hen harrier, Honey buzzard, Marsh harrier, Nightjar, Peregrine falcon, Short-eared owl, Woodlark	0	0.5	0.5
Black-tailed godwit, Brent goose, Curlew, Golden plover, Grey plover, Knot, Lapwing, Lesser black-backed gull, Oystercatcher, Pink-footed goose, Redshank, Ringed plover, Ruff, Sanderling, Snipe, Stone Curlew, White-fronted goose	0	0.7	0.1
Great crested newt, Natterjack toad, Stag beetle	0.1	0.9	0
Sand lizard, Smooth snake	0.2	0.8	0
Dormouse	0.3	0.6	0.1
Otter	0.5	0.5	0
Early gentian, Fen orchid, Petal wort, Shore dock[2]	1	0	0.5

[1]Assumed to spend large amount of time in the air - spreadsheets won't accept this, so as a conservative measure assumed higher proportion of time on water

[2]Values from Vives (2003)

The units for CF values used in the spreadsheets are as follows:

- **Aquatic ecosystems:**

  Sediment: Bq kg^{-1} (dry weight) of sediment per Bq m^{-3} (dissolved phase) in water

  Organisms: Bq kg^{-1} (fresh weight) of organism per Bq m^{-3} (dissolved phase) in water

- **Terrestrial ecosystem:**

  ^{3}H, ^{14}C, ^{32}P and ^{35}S:

  Soil: Bq kg^{-1} (fresh weight) of soil per Bq m^{-3} in air

  Organisms: Bq kg^{-1} (fresh weight) of organism per Bq m^{-3} in air.

  Other radionuclides:

  Organisms: Bq kg^{-1} (fresh weight) of organism per Bq kg^{-1} (dry weight) of soil.

Concentration factors (CFs) to be used in this assessment process have been derived, with limited success, from new literature sources. A useful source of new data on CFs for birds and one mammal has been the EPIC database (Beresford *et al.*, 2003).

CF bird values are particularly scarce, which is a problem given that the majority of the feature species are birds. To overcome this lack of CF data, it was decided to adopt the following approach that tries to maintain a realistic CF value but, given the lack of data, is also conservative:

a) Determine if a validated CF is available for the particular species and radionuclide of interest. If available this is used. If not available:

b) Determine if a CF is available from R&D Publication 128 for a reference organism of similar ecology, eg if it is a fish in a coastal environment, then use the CF value for a pelagic or benthic fish for the radionuclide of interest. If this is not available:

c) For aquatic ecosystems from R&D Publication 128, the CF values for the other reference organisms for the radionuclide of interest are considered. The highest CF value quoted is selected and compared with the value for the Kd for the radionuclide of interest. Then, the larger number is taken for use in the assessment.

For terrestrial ecosystems, in the terrestrial environment, it should generally be conservative to assume organism:soil CF of 1. There are some likely exceptions to this (eg iodine, caesium and technetium) but this is known because measurement data exist and therefore CFs should be determined from other reference organism data. Note also that this approach only works for CFs determined for organism:soil. In the terrestrial environment, ^{3}H, ^{14}C, ^{32}P and ^{35}S are all determined as organism:air because, principally, of the short half-life of the radionuclide or because they are reversible gases.

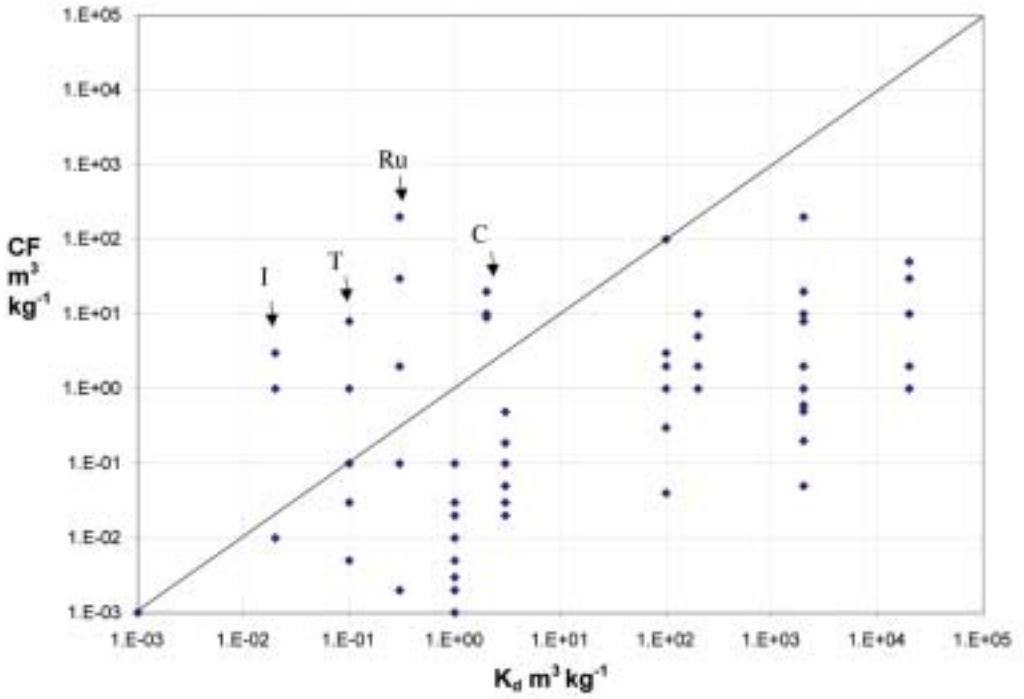
In the case of CFs for ^{32}P in air in terrestrial ecosystems it is felt that a sensible option is to take the CFs for ^{32}P as being the same as for ^{14}C. For radionuclides in air this assumption should be conservative: the ^{14}C factor assumes constant specific activity between air and organism, which is reasonable because most of the carbon in the terrestrial biosphere originates from photosynthesis and the half-life of ^{14}C is long enough for isotopic equilibration to take place. Since most of the ^{32}P in the biosphere arises from weathering of rocks and soil with very little atmospheric input, and the half-life of ^{32}P is short, it follows that ^{14}C CFs should provide a conservative value for ^{32}P CFs.

d) Where no CF or K_d values are available, the CF for the Environment Agency recommended analogue radionuclide (EA, 2002) is used. It should be noted that this approach might produce some extremely conservative concentration factors.

The origins of the concentration factors used should be taken into account when interpreting the outputs of dose rate assessments. If the assessment is marginal or if there are questions raised over the validity of the concentration or occupancy factors used, then this approach must be supported by field measurements to produce site-specific data. It is strongly recommended that a few sites should be considered for a site-specific data collection and assessment in order to demonstrate that the approach detailed in this report is robust and conservative. However it should be noted that if sampling for site-specific data were undertaken, the data would reflect both current and historic discharges. Consequently, the site-specific data should also be more conservative.

The use of K_d values in c) above can be justified as a being a good surrogate for CFs because most of the CF values in question are generally smaller than the K_d value quoted in R&D Publication 128. There are some exceptions, for example I, Tc, Ru and C. Interestingly, these are the only radionuclides in the data set that are likely to be present as anions. Consequently by selecting the highest CF for another reference organism, or the K_d value, the quoted CF for a particular feature species should be conservative given the data available.

Figure 4.2 | Plot of CF against K_d values for the reference organism geometries provided in R&D Publication 128.



The three categories "other alpha", "other beta" and "other gamma" for groups of radionuclides are used when the Environment Agency authorises discharges (see Appendix 1). In these cases it is not possible to identify specifically the radionuclide, or radionuclides, that form these categories. It is therefore recommend that:

- The assessor should determine the likely candidate radionuclides from gaining knowledge of the industrial process involved. The assessment should be run for each radionuclide that may be included in the "other" category, provided they are listed in the R&D Publication 128 spreadsheets; or
- In the absence of specific information, that the author's own selection of radionuclide is used to represent the above three categories for the assessment. The choice has been selected using a precautionary approach. In the absence of other data, the following radionuclides have been used to represent "other alpha", "other beta" and "other gamma" for this project. As previously, these should be conservative and thus provide upper estimates of the real dose rate. Radionuclide used to generate a CF value for:
- other alpha-emitting radionuclides ^{239}Pu
- other beta-emitting radionuclides ^{90}Sr (for terrestrial sites) or ^{99}Tc (for aquatic sites)
- other gamma-emitting radionuclides ^{137}Cs.

4.6 Derivation of dose per unit concentration values

At the request of the Environment Agency, a series of dose per unit concentration (DPUC) values have been calculated. These have been calculated based on the selected reference organism geometries, concentration factors and occupancy factor information for the different feature organisms. Tables of the total dose rate calculated are presented in Appendix 3. The spreadsheet in Appendix 5 also contain information on the internal and external dose rate components with both weighted and unweighted dose rates (weighting factors have been applied using the default values recommended in R&D Publication 128).

The units quoted for coastal aquatic, freshwater and terrestrial aerial doses (^{3}H, ^{14}C, ^{32}P, ^{35}S, ^{41}Ar and ^{85}Kr) are in μGy per hour per Bq per cubic metre, that is μGy h^{-1} Bq^{-1} m^{-3} of water for aquatic or air for gases.

The units quoted for terrestrial doses (all other nuclides in soil) are in μGy per hour per Bq per Kilogramme, that is μGy h^{-1} Bq^{-1} kg^{-1} of soil.

5. Research requirements

When trying to address the protection of the environment from the potential impact of ionising radiation, there is a need to consider not only the species of key conservation, economic or social value but also the environment as a whole.

It is clear from Sections 4.1 and 4.1.2 that there is a need to determine the best mechanism to demonstrate that feature habitats, ie SAC habitats that are protected under EA (2002) are adequately protected from the impact of ionising radiation per se. A basic approach to enable such an assessment to be made has been outlined in Chapter 3, but there is a need to extend this project to address the key component species identified for each feature habitat. This project has already identified which species should be considered (see Appendix 4) and it is suggested that representative reference organisms from R&D Publication 128 should be identified for these species along with concentration and occupancy factors. There are a number of high-priority sites however where a feature habitat is listed but no feature species have been identified (eg Dorset Heath which is a high-priority site in the south-west has only two feature species listed out of 16 feature habitat types). In this case, urgent action is required in order to develop the key component species concept to permit an impact assessment to be conducted, as outlined in this report, using the methodology in R&D Publication 128.

There is a need to better understand the ecological links within each ecosystem that may be impacted by ionising radiation in order to undertake a full assessment. It is recommended that the approach developed in Chapter 3 could be significantly improved by giving due consideration to the ecology of each feature species identified in each of the Natura 2000 sites. This is reflected in the very limited classification of prey items in Tables 4.1 and 4.2. The approach outlined in Chapter 3 does address the basic requirements under the Habitats Regulations but it is not comprehensive in its assessment for a number of reasons:

- limitations of the assessment tools produced in R&D Publication 128 (see Section 5.3);
- the lack of guidance in EA (2002) as to what criteria are needed to protect feature habitats;
- the need for assessors to have an understanding of the ecology of the feature species at the site under assessment.

It should be noted, however, that the approach listed in Chapter 3 and the underlying supporting work have been considered, wherever possible, from a precautionary point of view.

5.1 Data gaps

There are some data gaps that need to be filled before some Stage 3 Assessments can be carried out.

- are a number of radionuclides of potential significance in terms of impact on Natura 2000 sites which are not included in the three spreadsheets produced in R&D Publication 128. These include, for example, ^{99m}Tc. Consideration should be given to the inclusion of these radionuclides in the spreadsheets in order to reduce reliance on the use of analogues.
- Analogues, unless selected with great care, can give rise to misleading assessments. Analogues are often cautious because of the need to ensure a precautionary approach taking into account the uncertainties associated with their use. Analogues have been selected for one of two reasons:

  a) because of the lack of radionuclide-specific dose assessment factors in the spreadsheets; or

b) because of lack of data on appropriate concentration factors for use in the spreadsheets for specific species/radionuclide combinations.

- There is a large number of missing concentration factors for the species listed in Tables 4.1 and 4.2. It is also clear that it will not be possible to directly sample these species in order to determine appropriate concentration factors for the dose assessments. Therefore consideration should be given firstly to the use of techniques such as allometry for estimating appropriate concentration factors for use. Secondly, species with similar ecology to those listed in EA (2002), but that are not considered to be at risk from a conservation point of view, should be sampled to determine concentration factors. The following highlights and prioritises some of the significant data gaps that should be addressed.
- Field and laboratory work should be considered to identify missing CF values.
- Theoretical approaches to determine the missing CF values such as the use of allometric or phylogeny techniques should be considered. The use of stable element data should also be considered.
- Semi-empirical methods and systematic variation between chemical classes should be evaluated to determine whether any generalisations might be made to the determination of CF values.
- Additional data sources (for example, those held by other organisations ó such as the database of marine radioecology measurements held by the French nuclear company COGEMA) should be evaluated and new CFs determined.

5.2 Recommended upgrades to the assessment spreadsheets

The Stage 3 Assessment approach is pushing the spreadsheets produced in R&D Publication 128 beyond their original scope. The European project FASSET will produce information from which assessment tools can be developed and it may be that the spreadsheets in R&D Publication 128 need to be developed as a result of this new information. However, it is anticipated that the following suggestions should be considered for incorporation into any new assessment tool development. For example, the proposal ERICA (Environmental Risks from Ionising Contaminants: Assessment and Management) has been submitted to the European Commission under the EURATOM 6th Framework. If successful, it will ensure further development of the assessment tool over the next few years. It is hoped then that new tools will be available within three to four years. The following recommendations should be considered in the context of this proposal as well as the Environment Agency's assessment methodology outlined in R&D Publication 128.

It is recommended that the following options be considered firstly without modification of the existing dose assessment spreadsheets and then secondly with modifications.

a) Without modifying spreadsheets.

- Generating a simple spreadsheet 'geometry allocator' with a list of all the feature species that may be of interest to allow the user to choose, in a consistent and robust manner, the R&D Publication 128 reference organism geometry that best represents the feature species. The programme could also provide error estimation based on the area/volume calculation method.
- To refine the area/volume calculation method so that a more reliable estimate of the error associated with a substitute geometry is generated, examining the radionuclide dependency and worst case scenarios (as the current method only produces a basic radionuclide-independent average error).

b) With modification of the spreadsheets.

- Include the reference organisms, radionuclides and concentration factor data produced from within the FASSET framework (Larsson *et al.*, 2002).
- Include all the dosimetric data for the radionuclides with the potential to impact on Natura 2000 sites of interest (thus obviating the need for analogues to encompass dosimetry as well as environmental transfer).
- Change the user interface so that the user only has to enter the data for radionuclides of relevance to the site under consideration and specifying which radionuclides to produce results for (to avoid the problems of cumbersome graphical output containing an ever expanding list of radionuclides).
- Allow more flexible links between the CF and DPUC values so that a "build your own" reference organism approach is possible.
- Possible integration of the current three ecosystem spreadsheets into one which would allow greater flexibility in the selection of the DPUC values and thus allow the best substitute geometry to be selected.

5.3 General research requirements

The use of concentration factors should also be considered over the longer term. The concentration factor term integrates a number of processes and is only truly applicable under equilibrium conditions, which are frequently not observed in the environment. In the field, a wide range of concentration factors is frequently observed because the integrated uptake of radionuclides by an organism is often compared with an instantaneous water or soil/sediment measurement. Discharges of radionuclides from the nuclear industry often take the form of pulsed discharges that further complicate the interpretation of the term. Other factors that can affect concentration factors include speciation, salinity, competing ions etc. Therefore the approach adopted in the spreadsheets from R&D Publication 128 and in the approach described in Chapter 3 have been derived using concentration factors which should be conservative in order to be confident that the approach over predicts the dose rates to biota. It should also be noted that CF values are not always conservative because, in situations where there is a continuous input, directly intercepted deposition may become a significant component compared with root uptake.

Consideration should therefore be given to developing dynamic modelling approaches, which would eliminate the reliance on concentration factors and would be capable of predicting dose rates to biota over short-term periods. In addition, other problems such as specifically defining the method used for deriving a concentration factor should be addressed. For example, it is useful to differentiate between laboratory (where truly equilibrium conditions may be attained) and field measurements that may or may not be close to equilibrium.

Extending the issue of the use of concentration factors, consideration should be given to appropriate assessment methods for spatial, temporal and averaging of doses. For example, it is recommended that a scoping study is conducted to determine how time dependence-organism concentration in relation to time varying concentrations in air, soil and water might affect the results and thus appropriate modifications made to the dose assessment methodology.

At one or more of the sites under investigation, it is strongly recommended that a detailed site assessment should be carried out which will involve a limited amount of fieldwork for on-site and laboratory measurements in order to demonstrate that the theoretical approach for Stage 3 Assessments is robust. This will add confidence that the Stage 3 Assessment approach outlined is conservative. However, it should be noted that if sampling for site-specific data were undertaken, the data would reflect both current and historic discharges. Consequently, the site-specific data should also be more conservative.

6. Conclusions

This report provides a basic approach to the Stage 3 Assessment using the ecosystem (coastal, freshwater and terrestrial) dose assessment spreadsheets produced in R&D Publication 128 (Copplestone *et al.*, 2001). The basic approach, illustrated in Figure 3.1, can be used by Environment Agency staff who are conducting the Stage 3 Assessments in a standardised, robust manner, whilst referring to the site information sheets, in Appendix 4, that have been constructed for each Natura 2000 site. The assumptions and uncertainities related to particular values or aspects of the approach have been stated in the report (or elsewhere, for example R&D Publication 128 for the dose estimation methodology).

6.1 Information review

This report has reviewed information provided by the Environment Agency that has identified approximately 100 authorisations that have the potential to impact on Natura 2000 sites. The Natura 2000 sites have been identified and information has been gathered from the Environment Agency Habitats Database on the feature species and habitats that require protection under the Environment Agency EU Habitats and Birds Directives Handbook for Agency Permissions and Activities (EA, 2002). Each of these authorisations requires a Stage 3 Assessment in order to determine the potential for impact from ionising radiation.

A total of 81 species (55 birds, four plants, two terrestrial invertebrates, two amphibians, four terrestrial mammals, three aquatic mammals, one aquatic invertebrate, eight fish and two reptiles) were identified as needing protection at 51 Natura 2000 sites. In addition, 35 feature habitats were identified within some of those sites. It is important to realise that these feature habitats may have been designated for reasons other than the conservation status of species that they contain (eg for their physical features). Because of this, the key component species described within these feature habitats may be different to those feature species specifically listed.

The evaluation of these feature habitats was outside of the scope of this project, but where possible, key component species of these feature habitats have been recorded from additional information sources such as JNCC. This additional information could be used for further evaluation by the Environment Agency staff carrying out Stage 3 Assessments.

A review of the biological and ecological characteristics from literature sources was conducted in order to determine:

- organism dimensions;

- occupancy factors in different parts of the ecosystems;
- predator and prey species of the organism.

The dimensions were then used to determine the volume and area of each organism, which was represented as an ellipsoid. A critical evaluation of the geometry of each organism was then conducted in order to match each feature organism to an equivalent reference organism geometry from those listed in the R&D Publication 128 spreadsheets. It has proved possible to stylise and represent each identified feature species with an R&D Publication 128 reference organism.

It is the geometry which is important for the dosimetry, and therefore the name of the R&D Publication 128-reference organism should be taken only to represent the geometric shape - not the actual species. For example, in Table 4.6 we recommend that in an aquatic assessment a Bullhead should be represented by the R&D Publication 128 small aquatic mammal reference geometry. To reiterate, the geometric shape of a Bullhead (140 x 28 x 28cm) is best represented by the geometric shape of the small aquatic mammal reference geometry (100 x 20 x 20cm).

6.2 Guidance

This basic assessment process, as illustrated in Figure 3.1, will provide Environment Agency staff with a robust reproducible method for determining the likely impact of ionising radiation resulting from discharge permissions on Natura 2000 sites. However, it should be recognised that there are limitations to the approach, especially when considering feature habitats. Where possible, key component species have been identified and listed in the site information sheets although no attempt to link these key component species to particular R&D Publication 128 reference geometries or to locate appropriate concentration and occupancy factor information has been made. It is recommended that assessors give consideration to these factors when undertaking an assessment. Ideally the assessment should be carried out with full understanding and knowledge of the ecology, biology and environmental interactions for the feature species (and key component species), their predators and prey and source of the ionising radiation.

It has been recommended that an assessor modify the concentration factors and the initial concentration of radionuclide in the environment in one or more of the dose assessment spreadsheets provided in R&D Publication 128 for each necessary organism/radionuclide combination.

Appendix 3 contains a series of look-up tables of dose per unit concentration values. These have been calculated based on the selected reference organism geometries, concentration factors and occupancy factor information for the different feature organisms.

Appendix 4 catalogues site information sheets, sorted by EA Regions, containing recommended data input values and reference organism geometry information that best stylises and represents the feature species at each Natura 2000 site.

The report also includes an indication of which prey organisms should also be considered during the assessment by evaluating the dose rates predicted for particular reference groups (eg mollusc, small benthic crustacean etc) using the default parameter values within the dose assessment spreadsheets. Little data were obtained on predator species and therefore predators have been excluded from further study.

6.2.1 Concentration factors

A review of the scientific literature has revealed little data on the concentration of the radionuclides of interest in the feature species. This is not surprising, given that most of the feature species are of conservation value and therefore unlikely to be included in routine sampling and monitoring programmes. Some concentration factor data have been obtained (for example from the EC-part-funded EPIC project (Beresford *et al.*, 2003)) and from species with a similar ecology but which are not of conservation value and that have been sampled.

In the absence of feature species and radionuclide specific CF values, an approach has been developed, which should be conservative, to produce CF values for inclusion in the assessment. Essentially, the approach is as follows: determine if a CF is available for the species and radionuclide of interest. This is used if available. If not, a CF is determined from R&D Publication 128 for a reference organism with similar ecology. If this is not available, the CF and K_d values for the radionuclide of interest are reviewed and expert judgement is used to determine which value should be recommended.

Expert judgement is needed because although the use of the K_d to equate to CF can be viewed as generally conservative, certain radionuclides, eg ^{131}I, are known to accumulate in organisms and in these situations the use of the Kd is unlikely to be appropriate.

Finally, where no CF is available for another plant group or another animal group, the CF for the Environment Agency recommended analogue radionuclide (EA, 2002) has been used. It should be noted that this approach might produce some extremely conservative concentration factors.

The origins of the concentration factors used should be taken into account when interpreting the outputs of dose rate assessments. It is emphasised again that this approach must be supported by field measurements to produce site-specific data if there is any doubt over the results.

6.3 Research

Guidance has been provided on how such an assessment should be conducted, based on the findings of this work. Requirements for research that will assist in conducting the Stage 3 Assessments have been identified and recommended. The main points are:

- to include a number of additional radionuclides in the assessment tool spreadsheets;
- to consider allometric and phylogenetic techniques to identify CF values;
- to evaluate stable element data to determine CF values;
- to undertake field and laboratory measurements to determine appropriate CF values for the species of interest;
- to consider how to address the issue of protection for feature habitats where no feature species have been identified; and
- to consider the need for spatial, temporal and averaging of doses and to establish the techniques and tools to achieve this.

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Appendix 1:

Summary on sites and authorisations

Region	Site [1]	Permissions [2]	Stage 3 [3]	Radionuclides [4]
Southern	Dungeness cSAC, Spa & Ramsar	AA3549, AW9960, AM7079,AB1169, AE8208 AA3522, AS3641, AS3650, AS3676, AS3668, AE8216, AT8932, AS3404	Yes - T Yes - C N/a - F	Ar-41 (T - combination) Other alpha (T - Dungeness A) Cs-137 (C- Dungeness A) Other beta/gamma (C- combination)
Southern	Solent & Southhampton Water SPA & Ramsar	AZ8722,AL5160	Yes - C No - T N/A - F	C-14 (C - AL 5160) Other beta/gamma (C - AZ8722)
Southern	Portsmouth Harbour SPA & Ramsar	AV5381,AX2251,AI6846, AI1167,AV5381,BB2291	Yes - C No - T N/a - F	Tc-99m (C - combination)
Southern	Solent Maritime cSAC	AW6707,AD7443,BI1510	Yes - C N/A - T N/A -F	Tc-99m (C - BI 1510)
Southern	Chichester & Langstone Harbours SPA & Ramsar	AW6707,AD7443,BI1510	Yes - C N/A - T N/A - F	Tc-99m (C - BI 1510)
Southern	Wye & Crundale Downs cSAC	BH9060,BG0202	Yes - F N/A - T N/A - C	Tc-99m (F - BG0202) I-131 (F ñ BG0202)
Southern	New Forest cSAC, SPA & Ramsar	AL5160	Yes - C No - T N/a - F	C-14 (C - AL5160)
Southern	Stodmarsh cSAC, SPA & Ramsar	BG0121	Yes - F N/a - C N/a - T	Tc-99m (F - BG0121) I-131 (F - BG0121) Other beta/gamma (F - BG0121)
Southern	Blean Complex cSAC	BG0121	Yes - F N/a - C N/a - T	Tc-99m (F - BG0121) I-131 (F - BG0121) Other beta/gamma (F - BG0121)

See footnotes on page 63

Region	Site [1]	Permissions [2]	Stage 3 [3]	Radionuclides [4]
South West	Dorset Heaths	AE8097,AB8619,AJ3573, AQ4373,AE2226,AE6078, BH2863,AH1587,AU1968, AW1381,AU1089,AU1062	Yes - T N/a - C N'a - F	Kr-85 (T - AU1062 AEA Winfrith TC)
South West	Uphill Cliff SSSI/mendip Limestone Grasslands	AL2918	No - T N/a - C N/a - F	N/a
South West	Poole Harbour	AB8619,AJ3573,AE6833, BI1102,AE2218,AE6078	Yes - C N/a - T N/a - F	Any alpha (C - AE6833) I-131 (C - AE6833)
South West	Porton Down SPA	AB7345 AI4557 AE3672	Yes [5]	[5] discharges comprise H-3&C-14, S-35, P-32 I-125&I-131, others except alphas
South West	Hampshire & Avon cSAC	AI4557,BH2863,AH1587, AQ4373,AB7345,AE3672	Yes [5]	5] discharges comprise H-3&C-14, S-35, P-32, I-125&I-131, others except alphas
South West	Severn Estuary	Not yet completed	?	?[7]
South West	Tamar Estuary	AI0489,AU0520,AK9461, AQ4446,AR8919,AN7104	No - T No - C N/a - F	N/a
South West	Blackstone Point	AQ4446,AR8919,AN7104	No - T No - C N/a - F	N/a
North East	Teeside Sites [6]	All 25 extant permissions	Yes -C Yes [8] - F N/a - T	C-14 (C & F[8?] combination) Tc-99m (C - combination) Other alpha (C -on combination) Other beta/gamma (C -in combination)
North East	Humber Estuary sites	All extant permissions	Yes - C No - T N/a - F	Tc-99m (C - combination) I-131 (C - Cookridge Hospital) Other beta/gamma (C - combination) Assessment not yet complete - including remaining permissions may extend range of radionuclides
Thames (SE)	Thames Basin Heath pSPA	BA1001 BI9928 BH5767	Yes - F NO- T N/a - C	C-14, I-125, I-131, Tc-99m other beta-gamma assessed as P32 for BA1001 & BI9928; assessed as Co57 for BH5767,

See footnotes on page 63

Region	Site [1]	Permissions [2]	Stage 3 [3]	Radionuclides [4]
Thames (SE)	Wealden Heaths Phase II	BE9985 + 2 others	Yes - c	?Tc-99m
Thames (NE)	Lee Valley SPA & Ramsar	BH7062,BK7200,AO7592, BR6929,BR7097,BR7119, BR6988,BJ5309	Yes - F No - T ? - C	H-3(OB), C-14, P-32/33,S-35,Tc-99m,I-125, other beta/gamma (All F - combination)
Thames (W)	Oxford Meadows	AM8113	N - T N/a - F N/a - C	N/a
Thames (SE)	Thursley, Ash, Pirbright & Chobham cSAC	BA1001	Yes - F No - T N/a - C	C-14, I-125, Beta/Gamma (assessed P-32) (All F)
Thames (W)	Little Wittenham	BB1481 BH5994	N - F N/a - T N/a - C	N/a
Thames (W)	Chiltern Beechwoods cSAC	BG8840	N - F N/a - T N/a - C	N/a
Thames (W)	Pangbourne	?AWE Aldemaston	Y - F N/a - T N/a - C	[7]
North West (NW)	Cumbrian Coast Natura 2000 sites		No -C No - T No - F	
North West (NW)	Duddon Estuary SPA	2?	?	?[7]
North West (S)	Mersey Estuary SPA	AB8759,BK4871,BG6278	?	[7]
North West (S) Manchester	Manchester Moss Lands SAC Moss Lands SAC	AB6063,AB8902	No - T N/a - C? N/a - F?	N/a
North West (Cen)	Ribble and Alt SPA	?	?	[7]
EA Wales (SW) Kenfig	Kenfig	BQ3584	Yes - T No - C No - F	?[7]
EA Wales (SW)	Pembrokeshire Marine	BG3058,BL0979,AR3119	Yes - T No - C No - F	[7]

See footnotes on page 63

Region	Site [1]	Permissions [2]	Stage 3 [3]	Radionuclides [4]
EA Wales (SW)	Limestone Sea Cliff of SW Wales	AR3119	Yes - T No - C No- F	[7]
EA Wales (SW)	Castle martin Coast SPA	AR3119	Yes - T No - C No - F	[7]
EA Wales (SE)	N/a	Midlands		[7]
Anglian	BroadlandcSAC, SPA & Ramsar	BJ2776,BJ3543,AW6596,	Yes - F N/a - T N/a - C	Tc-99m, I-125. I-131, other beta gamma
Anglian	Breydon Water SPA	BJ2776,BJ3543,AW6596, BJ1036,BB0167,BH8276	Yes - F N/a - T N/a - C	Tc-99m, I-125, I-131, other beta/gamma
Anglian	Alde-Ore & Butley Estuaries SAC		Yes - ?	[7]
Anglian	Orfordness-Shingle Street SAC		Yes - ?	[7]
Anglian	Minsmere-Walberswick Heaths & Marshes SPA	AX4190,AJ7994,AF6642, AS3820,AL0648	Yes - T Yes - C N/a- F	Ar-41, other beta/gamma - T Cs-137, other alpha - C
Anglian	Sandlings SPA	AS3820,AL0648,AE7538	Yes - T No - F No - C	Ar-41, other beta/gamma
Anglian	Stour and Orwell Estuary SPA	AE7228,AZ1515,AF642	Yes - C No - T N/a - F?	I ñ 131, other alpha, other beta gamma
Anglian	Benfleet and Southend Marshes SPA		No - F No - C	N/a
Anglian	Essex Estuaries SAC	AB0804,BB1821,AB0812	Yes - T Yes - C Yes - F?	?-T Cs-137, other alpha - C Tc-99m, I-131, other beat/gamma - F
Anglian	Colne Esuary	BE1079,BL8511	Yes - C No - T N/a - F	Tc-99m
Anglian	Dengie	AB0812	Yes - C No - T N/a - F	Cs-137, other alpha

See footnotes on page 63

Region	Site [1]	Permissions [2]	Stage 3 [3]	Radionuclides [4]
Anglian	Alde-Ore Estuary	AX4190,AJ7994,AF6642	Yes - C N/a - T N/a - F	Cs-137, other alpha
Anglian	Mid Essex Coast SPA		Yes - ?	[7]
Anglian	Hamford Water SPA	BF7996,AZ1515,AE7228, BK0388	Yes - T Yes - T N/a - F	I-131. Other alpha, other beta/gamma
Anglian	Thames Estuary and Marshes SPA		Yes - ?	[7]
Anglian	Fenland cSAC		Yes - ?	[7]
Anglian	Ouse Washes cSAC & SPA		Yes - F? Y - C? No ñ T?	[7]
Anglian	Portholme Meadow cSAC	11 permits	Yes - T? Yes - F? N/a - C?	[7]
Anglian	The Wash and North Norfolk Coast cSAC& The Wash SPA	53 permits	Yes - F? N/a - C? N/a - T?	?[7]
Anglian	Saltfleetby - Theddlethorpe Dunes & Gibraltar Point cSAC		Yes - ?	[7]
Anglian	Humber Flats & Marshes SPA		Yes - ?	[7]
Anglian	Humber Flats & Marshes SPA		Yes - ?	[7]
Anglian	Nene Washes SPA		Yes - ?	[7]
Anglian	Nene Washes cSAC		Yes - ?	[7]
Anglian	Rutland Water SPA		Yes - ?	[7]

[1] For some sites (most especially estuarine locations and freshwater habitats downstream of significant river confluences), a further "in combination" assessment at stage 2 may yet be necessary.
[2] The listed permissions are those which the assessor has not screened out at stage 1 and which were therefore included in the stage 2 assessment.
[3] T = terestrial, C = coastal, F = Freshwater
[4] The listed radionuclides are those exceeding stage 2 screening levels - together with the relevant organism grouping (T, C, F) and whether the exceedance results from a single dischare or the combination of several
[6] Teesdide coastal Natura 2000 sites are effectively contiguous and were treated as one for this in combination assessment.
[5] Discharges from AI4557 are to groundwater and a precautionary need for stage 3 is assumed
[7] Where uncertainties about the relevant radionuclides remain the following group should be adopted;
Tc-99m, Cs-137, Sr-90, I-131, C-14, U-238

Appendix 2:

Amended tables of CFs from R&D Publication 128

The following tables are taken from the current versions of the concentration factors used in the dose assessment spreadsheets released with R&D Publication 128 modefied within this project to fill in the missing values (ie those shaded in the tables below) using the approach described in Section 4.5.

Table A2.1 *Concentration Factors (CFs) for the coastal aquatic spreadsheet - all radionuclides*

Nuclide	Kd	Bacteria	Phyto-plankton	Zoo plankton	Macro-phyte	Fish egg	Benthic mollusc	Small benthic crusta-cean	Large benthic crusta-cean	Pelagic fish	Benthic fish	Seabird	Seal	Whale
	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$
^{3}H	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
^{14}C	2.0E+00	2.0E+00	9.0E+00	2.0E+01	1.0E+01	2.0E+01	2.0E+01	2.0E+01	2.0E+01	2.0E+01	2.0E+01	2.0E+01	2.0E+01	2.0E+01
^{32}P	8.0E+00	8.0E+00	2.0E+00	2.0E+00	8.0E+00	8.0E+00	8.0E+00	8.0E+00	8.0E+00	8.0E+00	8.0E+00	8.0E+00	8.0E+00	8.0E+00
^{60}Co	2.0E+02	2.0E+02	5.0E+00	2.0E+00	1.0E+01	2.0E+02	5.0E+00	5.0E+00	5.0E+00	1.0E+00	1.0E+00	2.0E+02	2.0E+02	2.0E+02
^{90}Sr	1.0E+00	1.0E+00	3.0E-03	1.0E-03	5.0E-03	1.0E+00	1.0E-03	2.0E-03	2.0E-03	2.0E-03	2.0E-03	1.0E+00	1.0E+00	1.0E+00
^{99}Tc	1.0E-01	1.0E-01	5.0E-03	1.0E-01	1.0E+00	8.0E+00	1.0E+00	1.0E+00	8.0E+00	3.0E-02	3.0E-02	8.0E+00	8.0E+00	8.0E+00
^{106}Ru	3.0E-01	3.0E-01	2.0E+02	3.0E+01	2.0E+00	2.0E+02	2.0E+00	1.0E-01	1.0E-01	2.0E-03	2.0E-03	2.0E+02	2.0E+02	2.0E+02
^{125}I	2.0E-02	2.0E-02	1.0E+00	3.0E+00	1.0E+00	3.0E+00	1.0E-02	1.0E-02	1.0E-02	1.0E-02	1.0E-02	3.0E+00	3.0E+00	3.0E+00
^{129}I	2.0E-02	2.0E-02	1.0E+00	3.0E+00	1.0E+00	3.0E+00	1.0E-02	1.0E-02	1.0E-02	1.0E-02	1.0E-02	3.0E+00	3.0E+00	3.0E+00
^{131}I	2.0E-02	2.0E-02	1.0E+00	3.0E+00	1.0E+00	3.0E+00	1.0E-02	1.0E-02	1.0E-02	1.0E-02	1.0E-02	3.0E+00	3.0E+00	3.0E+00
^{137C}s	3.0E+00	3.0E+00	2.0E-02	3.0E-02	5.0E-02	3.0E+00	3.0E-02	3.0E-02	3.0E-02	1.0E-01	1.0E-01	3.0E+00	4.9E-01	1.9E-01
^{210}Po	2.0E+04	2.0E+04	3.0E+01	3.0E+01	1.0E+00	2.0E+04	1.0E+01	5.0E+01	5.0E+01	2.0E+00	2.0E+00	2.0E+04	2.0E+04	2.0E+04
^{234}Th	2.0E+03	2.0E+03	2.0E+01	1.0E+01	2.0E-01	2.0E+03	1.0E+00	1.0E+00	1.0E+00	6.0E-01	6.0E-01	2.0E+03	2.0E+03	2.0E+03
^{238}U	1.0E+00	1.0E+00	2.0E-02	5.0E-03	1.0E-01	1.0E+00	3.0E-02	1.0E-02	1.0E-02	1.0E-03	1.0E-03	1.0E+00	1.0E+00	1.0E+00
^{239}Pu	1.0E+02	1.0E+02	1.0E+02	1.0E+00	2.0E+00	1.0E+02	3.0E+00	3.0E-01	3.0E-01	4.0E-02	4.0E-02	1.0E+02	1.0E+02	1.0E+02
^{241}Am	2.0E+03	2.0E+03	2.0E+02	2.0E+00	8.0E+00	2.0E+03	2.0E+01	5.0E-01	5.0E-01	5.0E-02	5.0E-02	2.0E+03	2.0E+03	2.0E+03

Table A2.2 *Concentration Factors (CFs) for the freshwater spreadsheet - all radionuclides*

Nuclide	Kd	Bacteria	Phyto-plankton	Zoo-plankton	Macro-phyte	Benthic mollusc	Small benthic crusta-cean	Large benthic crusta-cean	Amphibian	Pelagic fish	Benthic fish	Aquatic mammal	Duck
	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$	$m^3\ kg^{-1}$
^{3}H	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
^{14}C	2.0E+00	2.0E+00	1.8E+00	4.0E+00	4.6E+00	7.3E+00	7.3E+00	7.3E+00	7.3E+00	4.6E+00	4.6E+00	7.3E+00	7.3E+00
^{32}P	5.0E+01	5.0E+01	2.0E+00	2.0E+00	1.0E+01	5.0E+01	5.0E+01	5.0E+01	5.0E+01	5.0E+01	5.0E+01	5.0E+01	5.0E+01
^{60}Co	5.0E+00	5.0E+00	1.0E+00	4.0E-01	1.0E+00	2.0E+00	2.0E+00	2.0E+00	5.0E+00	3.0E-01	3.0E-01	5.0E+00	5.0E+00
^{90}Sr	1.0E+00	1.0E+00	4.0E-02	2.0E-02	1.2E+00	2.5E-01	2.7E-01	2.7E-01	1.2E+00	4.3E-02	4.3E-02	1.2E+00	1.2E+00
^{99}Tc	5.0E-03	5.0E-03	8.0E-03	2.0E-02	1.3E+00	2.4E-02	1.3E-02	1.3E-02	1.3E+00	4.5E-02	4.5E-02	1.3E+00	1.3E+00
^{106}Ru	1.0E-01	1.0E-01	1.0E+01	6.0E+00	1.0E+01	1.0E+01	1.0E+01	1.0E+01	1.0E+01	1.0E-02	1.0E-02	1.0E+01	1.0E+01
^{125}I	1.0E-02	1.0E-02	2.0E-01	6.0E-01	4.0E-01	1.7E-01	1.7E-01	1.7E-01	6.0E-01	4.0E-02	4.0E-02	6.0E-01	6.0E-01
^{129}I	1.0E-02	1.0E-02	2.0E-01	6.0E-01	4.0E-01	1.7E-01	1.7E-01	1.7E-01	6.0E-01	4.0E-02	4.0E-02	6.0E-01	6.0E-01
^{131}I	1.0E-02	1.0E-02	2.0E-01	6.0E-01	4.0E-01	1.7E-01	1.7E-01	1.7E-01	6.0E-01	4.0E-02	4.0E-02	6.0E-01	6.0E-01
^{137}Cs	1.0E+00	1.0E+00	1.8E-01	2.0E-02	2.3E+00	5.8E-01	5.2E+00	6.3E-01	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
^{210}Po	2.7E+00	2.7E+00	6.0E+00	6.0E+00	1.4E+00	1.0E+02	1.0E+02	1.0E+02	1.0E+02	5.0E-02	5.0E-02	1.0E+02	1.0E+02
^{234}Th	1.0E+01	1.0E+01	4.0E+00	2.0E+00	3.0E+00	1.0E-01	1.0E-01	1.0E-01	1.0E+01	1.0E-01	1.0E-01	1.0E+01	1.0E+01
^{238}U	5.0E-02	5.0E-02	4.0E-03	1.0E-03	6.5E+00	1.8E-01	1.8E-01	1.8E-01	6.5E+00	1.0E-02	1.0E-02	6.5E+00	6.5E+00
^{239}Pu	1.0E+02	1.0E+02	1.8E-01	2.0E-02	1.8E+00	8.2E-01	1.4E-01	1.4E-01	1.0E+02	6.9E-02	6.9E-02	2.3E-01	2.0E-03
^{241}Am	5.0E+00	5.0E+00	4.0E+01	4.0E-01	3.0E+00	1.0E-01	1.0E-01	1.0E-01	4.0E+01	3.0E-02	3.0E-02	4.0E+01	4.0E+01

Table A2.3 *Concentration Factors (CFs) for the terrestrial spreadsheet - all radionuclides*

Nuclide	Dry:wet soil Bq kg^{-1}/Bq kg^{-1}	Bacteria m^3 kg^{-1}/kg kg^{-1}	Lichen m^3 kg^{-1}/ kg kg^{-1}	Tree m^3 kg^{-1}/kg kg^{-1}	Shrub m^3 kg^{-1}/kg kg^{-1}	Herb m^3 kg^{-1}/kg kg^{-1}	Seed m^3 kg^{-1}/ kg kg^{-1}	Fungi m^3 kg^{-1}/ kg kg^{-1}	Caterpillar m^3 kg^{-1}/kg kg^{-1}	Ant m^3 kg^{-1}/ kg kg^{-1}	Bee m^3 kg^{-1}/ kg kg^{-1}	Wood-louse m^3 kg^{-1}/ kg kg^{-1}	Earth-worm m^3 kg^{-1}/ kg kg^{-1}
^{3}H	5.4E+01	5.4E+01	1.6E+02	1.1E+02	1.5E+02	1.2E+02	8.9E+00	1.6E+02	1.5E+02	1.6E+02	1.5E+02	1.4E+02	1.5E+02
^{14}C	1.9E+03	1.9E+03	3.8E+01	1.3E+03	4.2E+02	5.6E+02	4.8E+03	3.8E+02	4.2E+02	2.8E+02	4.2E+02	5.6E+02	3.5E+02
^{32}P	1.9E+03	1.9E+03	3.8E+01	1.3E+03	4.2E+02	5.6E+02	4.8E+03	3.8E+02	4.2E+02	2.8E+02	4.2E+02	5.6E+02	3.5E+02
^{35}S	5.0E+01	5.0E+01	1.5E+02	1.5E+02	1.5E+02	1.5E+02	5.0E+01	5.0E+01	5.0E+01	5.0E+01	5.0E+01	5.0E+01	5.0E+01
^{41}Ar	1.0E-04	1.0E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
^{85}Kr	1.0E-04	1.0E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
^{60}Co	7.0E-01	7.9E-01	7.9E-01	7.9E-01	1.0E-02	1.0E-02	1.0E-02	7.9E-01	3.7E-03	3.7E-03	3.7E-03	7.9E-01	7.9E-01
^{90}Sr	7.0E-01	7.0E-01	5.0E+00	1.0E+00	1.7E-02	5.0E+00	5.0E+00	4.8E-03	5.0E+00	5.0E+00	5.0E+00	5.0E+00	5.0E+00
^{106}Ru	7.0E-01	1.5E+00	1.5E+00	1.5E+00	1.5E+00	1.5E+00	1.5E+00	1.5E+00	3.8E-03	3.8E-03	3.8E-03	1.5E+00	1.5E+00
^{129}I	7.0E-01	7.0E-01	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
^{131}I	7.0E-01	7.0E-01	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
^{137}Cs	7.0E-01	7.0E-01	7.7E-01	4.0E-02	1.6E-01	1.4E-01	9.0E+00	1.0E+00	9.0E+00	1.4E-02	1.6E-03	3.6E-02	1.3E-02
^{226}Ra	7.0E-01	7.0E-01	1.0E-01	1.1E-01	2.2E-01	1.9E-01	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00
^{234}Th	7.0E-01	1.0E-02	1.0E-02	1.0E-02	1.0E-02	1.0E-02	1.0E-03	1.0E-02	1.0E-02	1.0E-02	1.0E-02	1.0E-02	1.0E-02
^{238}U	7.0E-01	7.0E-01	7.0E-01	1.4E-01	2.0E-03	2.0E-03	7.0E-01	7.0E-01	7.0E-01	7.0E-01	7.0E-01	7.0E-01	7.0E-01
^{239}Pu	7.0E-01	7.0E-01	6.6E-01	3.7E-01	2.0E-03	2.0E-03	7.0E-01	7.0E-01	7.0E-01	1.4E-02	1.9E-03	4.5E-02	2.6E-02
^{241}Am	7.0E-01	7.0E-01	7.0E-01	1.5E-01	1.0E-04	1.0E-04	1.0E-04	7.0E-01	7.0E-01	1.4E-02	2.1E-03	3.7E-02	2.0E-02

Table A2.3 *Continued*

Nuclide	Herbivorous mammal $m^3 kg^{-1}$ /kg kg^{-1}	Carnivorous mammal $m^3 kg^{-1}$ /kg kg^{-1}	Rodent $m^3 kg^{-1}$ /kg kg^{-1}	Bird $m^3 kg^{-1}$ / kg kg^{-1}	Bird egg $m^3 kg^{-1}$ / kg kg^{-1}	Reptile $m^3 kg^{-1}$ / kg kg^{-1}
3H	1.3E+02	1.4E+02	1.4E+02	1.3E+02	1.5E+02	1.3E+02
14C	7.5E+02	6.9E+02	6.9E+02	7.0E+02	2.8E+02	7.0E+02
32P	7.5E+02	6.9E+02	6.9E+02	7.0E+02	2.8E+02	7.0E+02
35S	5.0E+01	5.0E+01	5.0E+01	5.0E+01	5.0E+01	5.0E+01
41Ar	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
85Kr	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
60Co	7.9E-01	7.9E-01	7.9E-01	7.9E-01	7.9E-01	7.9E-01
90Sr	5.0E+00	5.0E+00	5.0E+00	5.0E+00	5.0E+00	5.0E+00
106Ru	1.5E+00	1.5E+00	1.5E+00	1.5E+00	1.5E+00	1.5E+00
129I	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
131I	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
137Cs	2.2E+00	9.0E+00	1.3E-02	1.6E+00	9.0E+00	9.0E+00
226Ra	1.1E+00	1.1E+00	2.3E-02	6.0E-02	1.1E+00	1.1E+00
234Th	1.0E-04	1.0E-02	1.0E-02	1.0E-02	1.0E-02	1.0E-02
238U	4.0E-03	7.0E-01	2.0E-03	7.0E-01	7.0E-01	7.0E-01
239Pu	1.0E-04	7.0E-01	5.0E-04	7.0E-01	7.0E-01	7.0E-01
241Am	1.5E-04	7.0E-01	2.7E-04	7.0E-01	7.0E-01	7.0E-01

Appendix 3:

Dose per unit concentration (DPUC) lookup tables

Table A3.1 *(Weighted total) DPUC for marine spreadsheet - all radionuclides/species (μGy h^{-1} Bq^{-1} m^{3})*

Feature organism	^{3}H	^{14}C	^{32}P	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}I	^{129}I	^{131}I
Allis shad	9.84E-09	5.70E-04	3.12E-03	5.37E-03	1.76E-06	1.75E-06	2.70E-06	3.71E-07	5.33E-07	1.63E-06
Atlantic salmon	9.84E-09	5.70E-04	3.12E-03	5.37E-03	1.76E-06	1.75E-06	2.70E-06	3.71E-07	5.33E-07	1.63E-06
Avocet	9.84E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Bacteria	9.84E-09	2.28E-05	1.28E-03	1.20E-01	2.61E-04	2.37E-06	1.13E-04	4.08E-07	5.16E-07	2.84E-06
Bar-tailed godwit	9.84E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Benthic fish	9.84E-09	5.70E-04	3.11E-03	4.72E-02	6.63E-06	1.75E-06	1.13E-05	3.78E-07	5.41E-07	2.11E-06
Benthic mollusc	9.84E-09	5.68E-04	2.53E-03	5.76E-02	4.13E-05	5.76E-05	7.96E-04	3.49E-07	5.24E-07	2.04E-06
Bewicks swan	9.84E-09	5.71E-04	3.18E-03	1.07E-01	6.45E-04	4.67E-04	1.66E-01	1.12E-04	1.62E-04	5.74E-04
Bittern	9.84E-09	5.71E-04	3.18E-03	1.24E-01	6.45E-04	4.67E-04	1.66E-01	1.12E-04	1.62E-04	5.74E-04
Black-tailed godwit	9.84E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Brent goose	9.84E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Chough	9.84E-09	5.71E-04	3.18E-03	1.03E-01	6.44E-04	4.67E-04	1.66E-01	1.12E-04	1.62E-04	5.74E-04
Common scoter	9.84E-09	5.70E-04	3.12E-03	5.74E-02	6.30E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Common seal	9.84E-09	5.71E-04	3.18E-03	1.16E-01	6.45E-04	4.67E-04	1.66E-01	1.12E-04	1.62E-04	5.74E-04
Common tern	9.84E-09	5.70E-04	3.12E-03	5.74E-02	6.30E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Cormorant	9.84E-09	5.71E-04	3.18E-03	1.07E-01	6.45E-04	4.67E-04	1.66E-01	1.12E-04	1.62E-04	5.74E-04
Curlew	9.84E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Dunlin	9.84E-09	5.70E-04	3.12E-03	5.23E-02	6.29E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Fish egg	9.84E-09	5.48E-04	7.72E-04	1.04E-02	1.69E-04	4.12E-04	1.59E-02	7.10E-05	1.35E-04	2.43E-04
Gadwall	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04

Table A3.1 *Continued*

Feature organism	^{3}H	^{14}C	^{32}P	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}I	^{129}I	^{131}I
Gannet	9.84E-09	5.70E-04	3.12E-03	5.23E-02	6.29E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Golden plover	9.84E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Great crested grebe	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Grey plover	9.84E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Grey seal	9.84E-09	5.70E-04	3.19E-03	1.77E-01	6.49E-04	4.67E-04	1.75E-01	1.30E-04	1.72E-04	7.01E-04
Guillemot	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Hen harrier (male and female)	9.84E-09	5.70E-04	3.09E-03	4.95E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Kittewake	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Knot	9.84E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Lapwing	9.84E-09	5.71E-04	3.18E-03	1.24E-01	6.45E-04	4.67E-04	1.66E-01	1.12E-04	1.62E-04	5.74E-04
Large benthic crustacean	9.84E-09	5.68E-04	2.67E-03	5.74E-02	3.40E-05	4.62E-04	7.43E-05	3.52E-07	5.25E-07	2.05E-06
Lesser black-backed gull (male and female)	9.84E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Little tern	9.84E-09	5.70E-04	3.12E-03	5.74E-02	6.30E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Macrophyte	9.84E-09	2.76E-04	1.87E-03	1.16E-01	1.81E-04	5.27E-05	3.17E-04	2.42E-05	4.53E-05	8.78E-05
Manx shearwater	9.84E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Marsh harrier	9.84E-09	5.70E-04	3.09E-03	4.95E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Mediterranean gull	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Otter (female)	9.84E-09	5.70E-04	3.12E-03	6.78E-02	6.31E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Otter (male)	9.84E-09	5.71E-04	3.18E-03	1.16E-01	6.45E-04	4.67E-04	1.66E-01	1.12E-04	1.62E-04	5.74E-04
Oystercatcher	9.84E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Pelagic fish	9.84E-09	5.70E-04	3.11E-03	4.72E-02	6.63E-06	1.75E-06	1.13E-05	3.78E-07	5.41E-07	2.11E-06
Peregrine	9.84E-09	5.70E-04	3.12E-03	5.23E-02	6.29E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Phytoplankton	9.84E-09	1.76E-06	4.86E-07	2.53E-06	6.53E-07	5.90E-08	9.74E-05	7.89E-06	4.79E-06	4.83E-07
Pink-footed goose	9.84E-09	5.71E-04	3.18E-03	1.24E-01	6.45E-04	4.67E-04	1.66E-01	1.12E-04	1.62E-04	5.74E-04
Pintail	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Puffin	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Razorbill	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Redshank	9.84E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04

Table A3.1 *Continued*

Feature organism	^{3}H	^{14}C	^{32}P	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}I	^{129}I	^{131}I
Ringed plover	9.84E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
River lamprey	9.84E-09	5.70E-04	3.11E-03	4.72E-02	6.63E-06	1.75E-06	1.13E-05	3.78E-07	5.41E-07	2.11E-06
Ruff	9.84E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Sanderling	9.84E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Sandwich tern	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Scaup	9.84E-09	5.71E-04	3.18E-03	1.07E-01	6.45E-04	4.67E-04	1.66E-01	1.12E-04	1.62E-04	5.74E-04
Sea lamprey	9.84E-09	5.70E-04	3.13E-03	4.67E-02	5.62E-06	1.75E-06	1.07E-05	4.03E-07	5.53E-07	2.14E-06
Seabird	9.84E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Seal	9.84E-09	5.71E-04	3.18E-03	1.16E-01	6.45E-04	4.67E-04	1.66E-01	1.12E-04	1.62E-04	5.74E-04
Shelduck (female)	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Shelduck (male)	9.84E-09	5.70E-04	3.12E-03	5.74E-02	6.30E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Small benthic crustacean	9.83E-09	5.53E-04	1.50E-03	5.81E-02	8.73E-05	5.32E-05	6.13E-05	3.40E-07	5.16E-07	1.92E-06
Snipe	9.84E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Storm petrel	9.84E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Teal	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Tufted duck (female)	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Tufted duck (male)	9.84E-09	5.70E-04	3.12E-03	5.74E-02	6.30E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Turnstone	9.84E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Twaite shad	9.84E-09	5.70E-04	3.12E-03	5.37E-03	1.76E-06	1.75E-06	2.70E-06	3.71E-07	5.33E-07	1.63E-06
Whale	9.8E-09	5.70E-04	3.19E-03	1.63E-01	6.49E-04	4.67E-04	1.75E-01	1.30E-04	1.72E-04	7.01E-04
White-fronted goose	9.84E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	1.07E-04	1.57E-04	4.12E-04
Whooper swan	9.84E-09	5.71E-04	3.18E-03	1.07E-01	6.45E-04	4.67E-04	1.66E-01	1.12E-04	1.62E-04	5.74E-04
Wigeon	9.84E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	9.41E-05	1.50E-04	3.98E-04
Zooplankton	9.84E-09	5.52E-04	2.69E-04	1.11E-04	6.52E-07	5.31E-06	3.69E-03	7.15E-05	1.35E-04	2.64E-04

Table A3.1 *Continued*

Feature organism	^{137}Cs	^{210}Po	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Allis shad	3.57E-05	1.22E-01	1.50E-03	1.04E-04	2.37E-03	3.63E-03
Atlantic salmon	3.57E-05	1.22E-01	1.50E-03	1.04E-04	2.37E-03	3.63E-03
Avocet	6.48E-04	1.22E+03	9.88E-01	1.04E-01	5.93E+00	1.26E+02
Bacteria	5.63E-04	4.89E+02	4.19E-01	4.15E-02	2.37E+00	5.06E+01
Bar-tailed godwit	6.48E-04	1.22E+03	9.88E-01	1.04E-01	5.93E+00	1.26E+02
Benthic fish	1.77E-04	1.22E-01	1.28E-02	1.10E-04	2.38E-03	8.05E-03
Benthic mollusc	2.05E-04	6.11E-01	6.71E-02	3.14E-03	1.78E-01	1.27E+00
Bewicks swan	7.94E-04	1.22E+03	1.02E+00	1.04E-01	5.93E+00	1.26E+02
Bittern	8.46E-04	1.22E+03	1.02E+00	1.04E-01	5.93E+00	1.26E+02
Black-tailed godwit	6.48E-04	1.22E+03	9.88E-01	1.04E-01	5.93E+00	1.26E+02
Brent goose	6.48E-04	1.22E+03	9.88E-01	1.04E-01	5.93E+00	1.26E+02
Chough	7.81E-04	1.22E+03	1.02E+00	1.04E-01	5.93E+00	1.26E+02
Common scoter	5.96E-04	1.22E+03	9.91E-01	1.04E-01	5.93E+00	1.26E+02
Common seal	1.88E-04	1.22E+03	1.02E+00	1.04E-01	5.93E+00	1.26E+02
Common tern	5.96E-04	1.22E+03	9.91E-01	1.04E-01	5.93E+00	1.26E+02
Cormorant	7.94E-04	1.22E+03	1.02E+00	1.04E-01	5.93E+00	1.26E+02
Curlew	6.48E-04	1.22E+03	9.88E-01	1.04E-01	5.93E+00	1.26E+02
Dunlin	5.78E-04	1.22E+03	9.90E-01	1.04E-01	5.93E+00	1.26E+02
Fish egg	2.64E-04	1.22E+03	2.53E-01	1.03E-01	5.93E+00	1.26E+02
Gadwall	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Gannet	5.78E-04	1.22E+03	9.90E-01	1.04E-01	5.93E+00	1.26E+02
Golden plover	6.65E-04	1.22E+03	9.96E-01	1.04E-01	5.93E+00	1.26E+02
Great crested grebe	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Grey plover	6.65E-04	1.22E+03	9.96E-01	1.04E-01	5.93E+00	1.26E+02
Grey seal	2.01E-04	1.22E+03	1.03E+00	1.04E-01	5.93E+00	1.26E+02
Gulliemot	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Hen harrier (male and female)	5.59E-04	1.22E+03	9.81E-01	1.04E-01	5.93E+00	1.26E+02

Table A3.1 *Continued*

Feature organism	^{137}Cs	^{210}Po	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Kittewake	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Knot	6.65E-04	1.22E+03	9.96E-01	1.04E-01	5.93E+00	1.26E+02
Lapwing	8.46E-04	1.22E+03	1.02E+00	1.04E-01	5.93E+00	1.26E+02
Large benthic crustacean	2.03E-04	3.06E+00	5.50E-02	1.06E-03	1.78E-02	3.82E-02
Lesser black-backed gull (male and female)	6.48E-04	1.22E+03	9.88E-01	1.04E-01	5.93E+00	1.26E+02
Little tern	5.96E-04	1.22E+03	9.91E-01	1.04E-01	5.93E+00	1.26E+02
Macrophyte	4.54E-04	6.12E-02	2.96E-01	1.05E-02	1.19E-01	5.20E-01
Manx shearwater	6.48E-04	1.22E+03	9.88E-01	1.04E-01	5.93E+00	1.26E+02
Marsh harrier	5.59E-04	1.22E+03	9.81E-01	1.04E-01	5.93E+00	1.26E+02
Mediterranean gull	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Otter (female)	6.30E-04	1.22E+03	9.94E-01	1.04E-01	5.93E+00	1.26E+02
Otter (male)	1.88E-04	1.22E+03	1.02E+00	1.04E-01	5.93E+00	1.26E+02
Oystercatcher	6.48E-04	1.22E+03	9.88E-01	1.04E-01	5.93E+00	1.26E+02
Pelagic fish	1.77E-04	1.22E-01	1.28E-02	1.10E-04	2.38E-03	8.05E-03
Peregrine	5.78E-04	1.22E+03	9.90E-01	1.04E-01	5.93E+00	1.26E+02
Phytoplankton	4.77E-07	1.83E+00	1.79E-05	2.06E-03	5.93E+00	1.26E+01
Pink-footed goose	8.46E-04	1.22E+03	1.02E+00	1.04E-01	5.93E+00	1.26E+02
Pintail	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Puffin	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Razorbill	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Redshank	6.48E-04	1.22E+03	9.88E-01	1.04E-01	5.93E+00	1.26E+02
Ringed plover	6.48E-04	1.22E+03	9.88E-01	1.04E-01	5.93E+00	1.26E+02
River lamprey	1.77E-04	1.22E-01	1.28E-02	1.10E-04	2.38E-03	8.05E-03
Ruff	6.65E-04	1.22E+03	9.96E-01	1.04E-01	5.93E+00	1.26E+02
Sanderling	6.65E-04	1.22E+03	9.96E-01	1.04E-01	5.93E+00	1.26E+02
Sandwich tern	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Scaup	7.94E-04	1.22E+03	1.02E+00	1.04E-01	5.93E+00	1.26E+02
Sea lamprey	1.74E-04	1.22E-01	1.11E-02	1.09E-04	2.37E-03	7.36E-03

Table A3.1 *Continued*

Feature organism	^{137}Cs	^{210}Po	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Seabird	6.65E-04	1.22E+03	9.96E-01	1.04E-01	5.93E+00	1.26E+02
Seal	1.88E-04	1.22E+03	1.02E+00	1.04E-01	5.93E+00	1.26E+02
Shelduck (female)	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Shelduck (male)	5.96E-04	1.22E+03	9.91E-01	1.04E-01	5.93E+00	1.26E+02
Small benthic crustacean	2.25E-04	3.06E+00	1.43E-01	1.11E-03	1.78E-02	3.90E-02
Snipe	6.65E-04	1.22E+03	9.96E-01	1.04E-01	5.93E+00	1.26E+02
Storm petrel	6.48E-04	1.22E+03	9.88E-01	1.04E-01	5.93E+00	1.26E+02
Teal	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Tufted duck (female)	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Tufted duck (male)	5.96E-04	1.22E+03	9.91E-01	1.04E-01	5.93E+00	1.26E+02
Turnstone	6.48E-04	1.22E+03	9.88E-01	1.04E-01	5.93E+00	1.26E+02
Twaite shad	3.57E-05	1.22E-01	1.50E-03	1.04E-04	2.37E-03	3.63E-03
Whale	6.05E-05	1.22E+03	1.03E+00	1.04E-01	5.93E+00	1.26E+02
White-fronted goose	6.65E-04	1.22E+03	9.96E-01	1.04E-01	5.93E+00	1.26E+02
Whooper swan	7.94E-04	1.22E+03	1.02E+00	1.04E-01	5.93E+00	1.26E+02
Wigeon	5.77E-04	1.22E+03	9.82E-01	1.04E-01	5.93E+00	1.26E+02
Zooplankton	3.33E-06	1.83E+00	1.68E-03	5.17E-04	5.93E-02	1.26E-01

Table A3.2 *(Unweighted total) DPUC for marine spreadsheet - all radionuclides (μGy h^{-1} Bq^{-1} m^{-3})*

Feature organism	^{3}H	^{14}C	^{32}P	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}I	^{129}I	^{131}I
Allis shad	3.28E-09	5.70E-04	3.12E-03	5.37E-03	1.76E-06	1.75E-06	2.70E-06	2.50E-07	4.42E-07	1.63E-06
Atlantic salmon	3.28E-09	5.70E-04	3.12E-03	5.37E-03	1.76E-06	1.75E-06	2.70E-06	2.50E-07	4.42E-07	1.63E-06
Avocet	3.28E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Bacteria	3.28E-09	2.28E-05	1.28E-03	1.20E-01	2.61E-04	2.37E-06	1.13E-04	3.05E-07	4.38E-07	2.84E-06
Bar-tailed godwit	3.28E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Benthic fish	3.28E-09	5.70E-04	3.11E-03	4.72E-02	6.63E-06	1.75E-06	1.13E-05	2.57E-07	4.50E-07	2.11E-06
Benthic mollusc	3.28E-09	5.68E-04	2.53E-03	5.76E-02	4.13E-05	5.76E-05	7.96E-04	2.29E-07	4.34E-07	2.04E-06
Bewicks swan	3.28E-09	5.71E-04	3.18E-03	1.07E-01	6.45E-04	4.67E-04	1.66E-01	7.58E-05	1.35E-04	5.74E-04
Bittern	3.28E-09	5.71E-04	3.18E-03	1.24E-01	6.45E-04	4.67E-04	1.66E-01	7.58E-05	1.35E-04	5.74E-04
Black-tailed godwit	3.28E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Brent goose	3.28E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Chough	3.28E-09	5.71E-04	3.18E-03	1.03E-01	6.44E-04	4.67E-04	1.66E-01	7.58E-05	1.35E-04	5.73E-04
Common scoter	3.28E-09	5.70E-04	3.12E-03	5.74E-02	6.30E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Common seal	3.28E-09	5.71E-04	3.18E-03	1.16E-01	6.45E-04	4.67E-04	1.66E-01	7.58E-05	1.35E-04	5.74E-04
Common tern	3.28E-09	5.70E-04	3.12E-03	5.74E-02	6.30E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Cormorant	3.28E-09	5.71E-04	3.18E-03	1.07E-01	6.45E-04	4.67E-04	1.66E-01	7.58E-05	1.35E-04	5.74E-04
Curlew	3.28E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Dunlin	3.28E-09	5.70E-04	3.12E-03	5.23E-02	6.29E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Fish egg	3.28E-09	5.48E-04	7.72E-04	1.04E-02	1.69E-04	4.12E-04	1.59E-02	3.47E-05	1.08E-04	2.43E-04
Gadwall	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Gannet	3.28E-09	5.70E-04	3.12E-03	5.23E-02	6.29E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Golden plover	3.28E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Great crested grebe	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Grey plover	3.28E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Grey seal	3.28E-09	5.70E-04	3.19E-03	1.77E-01	6.49E-04	4.67E-04	1.75E-01	9.39E-05	1.44E-04	7.01E-04

Table A3.2 *Continued*

Feature organism	^{3}H	^{14}C	^{32}P	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}I	^{129}I	^{131}I
Guillemot	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Hen harrier (male and female)	3.28E-09	5.70E-04	3.09E-03	4.95E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Kittewake	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Knot	3.28E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Lapwing	3.28E-09	5.71E-04	3.18E-03	1.24E-01	6.45E-04	4.67E-04	1.66E-01	7.58E-05	1.35E-04	5.74E-04
Large benthic crustacean	3.28E-09	5.68E-04	2.67E-03	5.74E-02	3.40E-05	4.62E-04	7.43E-05	2.31E-07	4.35E-07	2.05E-06
Lesser black-backed gull (male and female)	3.28E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Little tern	3.28E-09	5.70E-04	3.12E-03	5.74E-02	6.30E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Macrophyte	3.28E-09	2.76E-04	1.87E-03	1.16E-01	1.81E-04	5.27E-05	3.17E-04	1.21E-05	3.62E-05	8.77E-05
Manx shearwater	3.28E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Marsh harrier	3.28E-09	5.70E-04	3.09E-03	4.95E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Mediterranean gull	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Otter (female)	3.28E-09	5.70E-04	3.12E-03	6.78E-02	6.31E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Otter (male)	3.28E-09	5.71E-04	3.18E-03	1.16E-01	6.45E-04	4.67E-04	1.66E-01	7.58E-05	1.35E-04	5.74E-04
Oystercatcher	3.28E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Pelagic fish	3.28E-09	5.70E-04	3.11E-03	4.72E-02	6.63E-06	1.75E-06	1.13E-05	2.57E-07	4.50E-07	2.11E-06
Peregrine	3.28E-09	5.70E-04	3.12E-03	5.23E-02	6.29E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Phytoplankton	3.28E-09	1.76E-06	4.86E-07	2.53E-06	6.53E-07	5.90E-08	9.74E-05	2.88E-06	1.89E-06	4.60E-07
Pink-footed goose	3.28E-09	5.71E-04	3.18E-03	1.24E-01	6.45E-04	4.67E-04	1.66E-01	7.58E-05	1.35E-04	5.74E-04
Pintail	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Puffin	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Razorbill	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Redshank	3.28E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Ringed plover	3.28E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
River lamprey	3.28E-09	5.70E-04	3.11E-03	4.72E-02	6.63E-06	1.75E-06	1.13E-05	2.57E-07	4.50E-07	2.11E-06
Ruff	3.28E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Sanderling	3.28E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Sandwich tern	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04

Table A3.2 *Continued*

Feature organism	^{3}H	^{14}C	^{32}P	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}I	^{129}I	^{131}I
Scaup	3.28E-09	5.71E-04	3.18E-03	1.07E-01	6.45E-04	4.67E-04	1.66E-01	7.58E-05	1.35E-04	5.74E-04
Sea lamprey	3.28E-09	5.70E-04	3.13E-03	4.67E-02	5.62E-06	1.75E-06	1.07E-05	2.82E-07	4.63E-07	2.14E-06
Seabird	3.28E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Seal	3.28E-09	5.71E-04	3.18E-03	1.16E-01	6.45E-04	4.67E-04	1.66E-01	7.58E-05	1.35E-04	5.74E-04
Shelduck (female)	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Shelduck (male)	3.28E-09	5.70E-04	3.12E-03	5.74E-02	6.30E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Small benthic crustacean	3.28E-09	5.53E-04	1.50E-03	5.81E-02	8.73E-05	5.32E-05	6.13E-05	2.19E-07	4.25E-07	1.92E-06
Snipe	3.28E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Storm petrel	3.28E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Teal	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Tufted duck (female)	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Tufted duck (male)	3.28E-09	5.70E-04	3.12E-03	5.74E-02	6.30E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Turnstone	3.28E-09	5.70E-04	3.11E-03	7.56E-02	6.27E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Twaite shad	3.28E-09	5.70E-04	3.12E-03	5.37E-03	1.76E-06	1.75E-06	2.70E-06	2.50E-07	4.42E-07	1.63E-06
Whale	3.28E-09	5.70E-04	3.19E-03	1.63E-01	6.49E-04	4.67E-04	1.75E-01	9.39E-05	1.44E-04	7.01E-04
White-fronted goose	3.28E-09	5.70E-04	3.13E-03	7.81E-02	6.31E-04	4.67E-04	1.53E-01	7.03E-05	1.30E-04	4.12E-04
Whooper swan	3.28E-09	5.71E-04	3.18E-03	1.07E-01	6.45E-04	4.67E-04	1.66E-01	7.58E-05	1.35E-04	5.74E-04
Wigeon	3.28E-09	5.70E-04	3.10E-03	5.47E-02	6.24E-04	4.66E-04	1.51E-01	5.78E-05	1.23E-04	3.98E-04
Zooplankton	3.28E-09	5.52E-04	2.69E-04	1.11E-04	6.52E-07	5.31E-06	3.69E-03	3.52E-05	1.08E-04	2.64E-04

Table A3.2 *Continued*

Feature organism	^{210}Po	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Allis shad	6.11E-03	1.49E-03	6.30E-06	1.19E-04	6.26E-04
Atlantic salmon	6.11E-03	1.49E-03	6.30E-06	1.19E-04	6.26E-04
Avocet	6.11E+01	9.85E-01	5.66E-03	2.97E-01	6.39E+00
Bacteria	2.45E+01	4.18E-01	2.28E-03	1.19E-01	2.57E+00
Bar-tailed godwit	6.11E+01	9.85E-01	5.66E-03	2.97E-01	6.39E+00
Benthic fish	6.13E-03	1.28E-02	1.21E-05	1.23E-04	5.04E-03
Benthic mollusc	3.06E-02	6.71E-02	1.99E-04	8.91E-03	7.05E-02
Bewicks swan	6.11E+01	1.02E+00	5.68E-03	2.97E-01	6.40E+00
Bittern	6.11E+01	1.02E+00	5.68E-03	2.97E-01	6.40E+00
Black-tailed godwit	6.11E+01	9.85E-01	5.66E-03	2.97E-01	6.39E+00
Brent goose	6.11E+01	9.85E-01	5.66E-03	2.97E-01	6.39E+00
Chough	6.11E+01	1.02E+00	5.68E-03	2.97E-01	6.40E+00
Common scoter	6.11E+01	9.89E-01	5.67E-03	2.97E-01	6.39E+00
Common seal	6.11E+01	1.02E+00	5.68E-03	2.97E-01	6.40E+00
Common tern	6.11E+01	9.89E-01	5.67E-03	2.97E-01	6.39E+00
Cormorant	6.11E+01	1.02E+00	5.68E-03	2.97E-01	6.40E+00
Curlew	6.11E+01	9.85E-01	5.66E-03	2.97E-01	6.39E+00
Dunlin	6.11E+01	9.87E-01	5.67E-03	2.97E-01	6.39E+00
Fish egg	6.11E+01	2.50E-01	5.30E-03	2.97E-01	6.38E+00
Gadwall	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Gannet	6.11E+01	9.87E-01	5.67E-03	2.97E-01	6.39E+00
Golden plover	6.11E+01	9.93E-01	5.67E-03	2.97E-01	6.40E+00
Great crested grebe	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Grey plover	6.11E+01	9.93E-01	5.67E-03	2.97E-01	6.40E+00
Grey seal	6.11E+01	1.03E+00	5.69E-03	2.97E-01	6.41E+00
Gulliemot	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Hen harrier (male and female)	6.11E+01	9.78E-01	5.66E-03	2.97E-01	6.39E+00

Table A3.2 *Continued*

Feature organism	^{210}Po	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Kittewake	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Knot	6.11E+01	9.93E-01	5.67E-03	2.97E-01	6.40E+00
Lapwing	6.11E+01	1.02E+00	5.68E-03	2.97E-01	6.40E+00
Large benthic crustacean	1.53E-01	5.50E-02	8.31E-05	8.97E-04	8.17E-03
Lesser black-backed gull (male and female)	6.11E+01	9.85E-01	5.66E-03	2.97E-01	6.39E+00
Little tern	6.11E+01	9.89E-01	5.67E-03	2.97E-01	6.39E+00
Macrophyte	3.10E-03	2.96E-01	6.81E-04	5.95E-03	4.01E-02
Manx shearwater	6.11E+01	9.85E-01	5.66E-03	2.97E-01	6.39E+00
Marsh harrier	6.11E+01	9.78E-01	5.66E-03	2.97E-01	6.39E+00
Mediterranean gull	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Otter (female)	6.11E+01	9.91E-01	5.67E-03	2.97E-01	6.40E+00
Otter (male)	6.11E+01	1.02E+00	5.68E-03	2.97E-01	6.40E+00
Oystercatcher	6.11E+01	9.85E-01	5.66E-03	2.97E-01	6.39E+00
Pelagic fish	6.13E-03	1.28E-02	1.21E-05	1.23E-04	5.04E-03
Peregrine	6.11E+01	9.87E-01	5.67E-03	2.97E-01	6.39E+00
Phytoplankton	9.17E-02	1.09E-05	1.04E-04	2.97E-01	6.32E-01
Pink-footed goose	6.11E+01	1.02E+00	5.68E-03	2.97E-01	6.40E+00
Pintail	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Puffin	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Razorbill	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Redshank	6.11E+01	9.85E-01	5.66E-03	2.97E-01	6.39E+00
Ringed plover	6.11E+01	9.85E-01	5.66E-03	2.97E-01	6.39E+00
River lamprey	6.13E-03	1.28E-02	1.21E-05	1.23E-04	5.04E-03
Ruff	6.11E+01	9.93E-01	5.67E-03	2.97E-01	6.40E+00
Sanderling	6.11E+01	9.93E-01	5.67E-03	2.97E-01	6.40E+00
Sandwich tern	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Scaup	6.11E+01	1.02E+00	5.68E-03	2.97E-01	6.40E+00
Sea lamprey	6.13E-03	1.11E-02	1.12E-05	1.21E-04	4.36E-03

Table A3.2 *Continued*

Feature organism	^{210}Po	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Seabird	6.11E+01	9.93E-01	5.67E-03	2.97E-01	6.40E+00
Seal	6.11E+01	1.02E+00	5.68E-03	2.97E-01	6.40E+00
Shelduck (female)	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Shelduck (male)	6.11E+01	9.89E-01	5.67E-03	2.97E-01	6.39E+00
Small benthic crustacean	1.53E-01	1.43E-01	1.25E-04	8.99E-04	8.98E-03
Snipe	6.11E+01	9.93E-01	5.67E-03	2.97E-01	6.40E+00
Storm petrel	6.11E+01	9.85E-01	5.66E-03	2.97E-01	6.39E+00
Teal	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Tufted duck (female)	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Tufted duck (male)	6.11E+01	9.89E-01	5.67E-03	2.97E-01	6.39E+00
Turnstone	6.11E+01	9.85E-01	5.66E-03	2.97E-01	6.39E+00
Twaite shad	6.11E-03	1.49E-03	6.30E-06	1.19E-04	6.26E-04
Whale	6.11E+01	1.03E+00	5.69E-03	2.97E-01	6.41E+00
White-fronted goose	6.11E+01	9.93E-01	5.67E-03	2.97E-01	6.40E+00
Whooper swan	6.11E+01	1.02E+00	5.68E-03	2.97E-01	6.40E+00
Wigeon	6.11E+01	9.80E-01	5.66E-03	2.97E-01	6.39E+00
Zooplankton	9.17E-02	1.66E-03	2.70E-05	2.97E-03	6.38E-03

Table A3.3 *(Weighted total) DPUC for freshwater spreadsheet - all radionuclides/species (μGy h^{-1} Bq^{-1} m^{-3})*

Feature organism	^{3}H	^{14}C	^{32}P	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}I	^{129}I	^{131}I
Allis shad	9.84E-09	1.31E-04	1.95E-02	1.93E-04	2.73E-05	2.63E-06	8.16E-06	1.43E-06	2.10E-06	5.71E-06
Amphibian	9.84E-09	2.08E-04	1.93E-02	2.21E-03	7.46E-04	7.57E-05	7.36E-03	1.87E-05	2.99E-05	7.54E-05
Aquatic mammal	9.84E-09	2.08E-04	1.77E-02	7.68E-04	6.68E-04	7.55E-05	5.75E-03	1.67E-05	2.88E-05	6.97E-05
Atlantic salmon	9.84E-09	1.31E-04	1.95E-02	1.93E-04	2.73E-05	2.63E-06	8.16E-06	1.43E-06	2.10E-06	5.71E-06
Avocet	9.84E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.87E-05	2.98E-05	7.52E-05
Bacteria	9.84E-09	2.28E-05	8.02E-03	3.00E-03	2.61E-04	1.52E-07	3.80E-05	2.18E-07	2.76E-07	1.52E-06
Bar-tailed godwit	9.84E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.87E-05	2.98E-05	7.52E-05
Benthic fish	9.84E-09	1.31E-04	1.94E-02	1.23E-03	3.20E-05	2.63E-06	1.09E-05	1.29E-06	2.03E-06	5.73E-06
Benthic mollusc	9.84E-09	2.07E-04	1.58E-02	1.57E-03	1.54E-04	1.38E-06	3.83E-03	4.38E-06	7.97E-06	1.89E-05
Bewicks swan	9.84E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.25E-05
Bittern	9.84E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.25E-05
Black-tailed godwit	9.84E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.87E-05	2.98E-05	7.52E-05
Brent goose	9.84E-09	2.08E-04	1.94E-02	1.89E-03	7.51E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.98E-05
Brook lamprey	9.84E-09	1.31E-04	1.96E-02	1.22E-03	3.12E-05	2.63E-06	1.08E-05	1.45E-06	2.11E-06	5.91E-06
Bullhead	9.84E-09	1.31E-04	1.93E-02	1.27E-03	3.30E-05	2.63E-06	1.10E-05	1.28E-06	2.01E-06	5.43E-06
Common scoter	9.84E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.25E-05
Cormorant	9.84E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.25E-05
Curlew	9.84E-09	2.08E-04	1.94E-02	1.89E-03	7.51E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.98E-05
Desmoulins whorl snail	9.84E-09	2.07E-04	1.49E-02	4.26E-04	1.21E-04	1.38E-06	3.82E-03	4.35E-06	7.95E-06	1.87E-05
Duck	9.84E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.25E-05
Dunlin	9.84E-09	2.08E-04	1.95E-02	1.31E-03	7.55E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.25E-05
Early gentian	9.84E-09	1.26E-04	6.80E-03	2.95E-03	4.23E-04	6.82E-05	1.12E-03	9.72E-06	1.81E-05	3.55E-05
Fen orchid	9.84E-09	1.26E-04	6.80E-03	2.95E-03	4.23E-04	6.82E-05	1.12E-03	9.72E-06	1.81E-05	3.55E-05
Gadwall	9.84E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.97E-05
Golden plover	9.84E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.26E-05

Table A3.3 *Continued*

Feature organism	^{3}H	^{14}C	^{32}P	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}I	^{129}I	^{131}I
Great crested grebe	9.84E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.97E-05
Great crested newt	9.84E-09	2.08E-04	1.93E-02	1.80E-03	7.44E-04	7.57E-05	7.36E-03	1.87E-05	2.98E-05	7.52E-05
Grey plover	9.84E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.26E-05
Hen harrier (female)	9.84E-09	2.08E-04	1.93E-02	1.24E-03	7.48E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.97E-05
Hen harrier (male)	9.84E-09	2.08E-04	1.92E-02	9.85E-04	7.40E-04	7.57E-05	7.35E-03	1.86E-05	2.98E-05	7.50E-05
Knot	9.84E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.26E-05
Lapwing	9.84E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.26E-05
Large benthic crustacean	9.84E-09	2.07E-04	1.67E-02	1.58E-03	1.63E-04	7.22E-07	4.53E-03	4.45E-06	8.00E-06	1.95E-05
Lesser black-backed gull (female)	9.84E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.87E-05	2.98E-05	7.52E-05
Lesser black-backed gull (male)	9.84E-09	2.08E-04	1.94E-02	1.89E-03	7.51E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.98E-05
Macrophyte	9.84E-09	1.26E-04	6.80E-03	2.95E-03	4.23E-04	6.82E-05	1.12E-03	9.71E-06	1.81E-05	3.54E-05
Marsh harrier	9.84E-09	2.08E-04	1.93E-02	1.24E-03	7.48E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.97E-05
Mediterranean gull	9.84E-09	2.08E-04	1.92E-02	1.12E-03	7.40E-04	7.57E-05	7.35E-03	1.86E-05	2.98E-05	7.50E-05
Natterjack toad	9.84E-09	2.08E-04	1.93E-02	1.80E-03	7.44E-04	7.57E-05	7.36E-03	1.87E-05	2.98E-05	7.52E-05
Otter (male and female)	9.84E-09	2.08E-04	1.95E-02	1.70E-03	7.56E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.26E-05
Oystercatcher	9.84E-09	2.08E-04	1.94E-02	1.89E-03	7.51E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.98E-05
Pelagic fish	9.84E-09	1.31E-04	1.94E-02	1.23E-03	3.20E-05	2.63E-06	1.09E-05	1.29E-06	2.03E-06	5.73E-06
Phytoplankton	9.84E-09	3.75E-07	4.86E-07	1.71E-06	6.57E-07	5.93E-08	5.77E-06	1.61E-06	1.00E-06	3.60E-07
Pink-footed goose	9.84E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.26E-05
Pintail	9.84E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.97E-05
Redshank	9.84E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.87E-05	2.98E-05	7.52E-05
Ringed plover	9.84E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.87E-05	2.98E-05	7.52E-05
River lamprey	9.84E-09	1.31E-04	1.81E-02	1.29E-03	4.15E-05	2.62E-06	1.24E-05	1.15E-06	1.94E-06	5.10E-06
Ruff	9.84E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.26E-05
Sanderling	9.84E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.26E-05
Scaup	9.84E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.25E-05
Sea lamprey	9.84E-09	1.31E-04	1.96E-02	1.22E-03	3.12E-05	2.63E-06	1.08E-05	1.45E-06	2.11E-06	5.91E-06
Shelduck (female)	9.84E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.97E-05

Table A3.3 *Continued*

Feature organism	^{3}H	^{14}C	^{32}P	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}I	^{129}I	^{131}I
Shelduck (male)	9.84E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.25E-05
Shoveler	9.84E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.97E-05
Small benthic crustacean	9.83E-09	2.02E-04	9.39E-03	1.56E-03	1.45E-04	6.71E-07	1.24E-03	4.10E-06	7.71E-06	1.57E-05
Snipe	9.84E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.26E-05
Southern damselfly	9.84E-09	2.07E-04	1.55E-02	1.35E-03	5.67E-04	7.48E-05	3.82E-03	1.53E-05	2.80E-05	6.55E-05
Spined loach	9.84E-09	1.31E-04	1.91E-02	1.80E-04	2.70E-05	2.63E-06	7.94E-06	1.26E-06	2.00E-06	5.22E-06
Teal (female)	9.84E-09	2.08E-04	1.92E-02	1.12E-03	7.40E-04	7.57E-05	7.35E-03	1.86E-05	2.98E-05	7.50E-05
Teal (male)	9.84E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.97E-05
Tufted duck (female)	9.84E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.97E-05
Tufted duck (male)	9.84E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.25E-05
Turnstone	9.84E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.87E-05	2.98E-05	7.52E-05
Twaite shad	9.84E-09	1.31E-04	1.95E-02	1.93E-04	2.73E-05	2.63E-06	8.16E-06	1.43E-06	2.10E-06	5.71E-06
White-fronted goose	9.84E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.26E-05
Whooper swan	9.84E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	2.13E-05	3.14E-05	8.25E-05
Wigeon	9.84E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.88E-05	3.01E-05	7.97E-05
Zooplankton	9.84E-09	1.10E-04	2.69E-04	2.33E-05	4.81E-06	1.07E-06	7.39E-04	1.43E-05	2.71E-05	5.30E-05

Table A3.3 *Continued*

Feature organism	^{137}Cs	^{210}Po	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Allis shad	1.98E-03	3.06E-03	5.54E-05	1.04E-03	4.11E-03	1.90E-03
Amphibian	1.84E-03	6.23E+00	4.92E-03	6.74E-01	5.93E+00	2.53E+00
Aquatic mammal	1.63E-03	6.23E+00	4.41E-03	6.73E-01	1.34E-02	2.53E+00
Atlantic salmon	1.98E-03	3.06E-03	5.54E-05	1.04E-03	4.11E-03	1.90E-03
Avocet	1.81E-03	6.23E+00	4.89E-03	6.74E-01	1.21E-04	2.53E+00
Bacteria	1.88E-04	6.61E-02	2.10E-03	2.14E-03	2.37E+00	1.27E-01
Bar-tailed godwit	1.81E-03	6.23E+00	4.89E-03	6.74E-01	1.21E-04	2.53E+00
Benthic fish	1.96E-03	3.06E-03	1.12E-04	1.04E-03	4.11E-03	1.91E-03
Benthic mollusc	1.45E-04	6.23E+00	3.69E-04	1.86E-02	4.86E-02	6.34E-03
Bewicks swan	1.99E-03	6.23E+00	4.96E-03	6.74E-01	1.19E-04	2.53E+00
Bittern	1.99E-03	6.23E+00	4.96E-03	6.74E-01	1.19E-04	2.53E+00
Black-tailed godwit	1.81E-03	6.23E+00	4.89E-03	6.74E-01	1.21E-04	2.53E+00
Brent goose	1.95E-03	6.23E+00	4.94E-03	6.74E-01	1.22E-04	2.53E+00
Brook lamprey	2.03E-03	3.06E-03	1.03E-04	1.04E-03	4.11E-03	1.91E-03
Bullhead	1.83E-03	3.06E-03	1.22E-04	1.04E-03	4.11E-03	1.91E-03
Common scoter	1.99E-03	6.23E+00	4.96E-03	6.74E-01	1.19E-04	2.53E+00
Cormorant	1.99E-03	6.23E+00	4.96E-03	6.74E-01	1.19E-04	2.53E+00
Curlew	1.95E-03	6.23E+00	4.94E-03	6.74E-01	1.22E-04	2.53E+00
Desmoulins whorl snail	9.13E-05	6.23E+00	1.03E-04	1.86E-02	4.86E-02	6.33E-03
Duck	1.99E-03	6.23E+00	4.96E-03	6.74E-01	1.19E-04	2.53E+00
Dunlin	1.99E-03	6.23E+00	4.95E-03	6.74E-01	1.19E-04	2.53E+00
Early gentian	3.72E-04	8.56E-02	1.94E-03	6.72E-01	1.07E-01	1.90E-01
Fen orchid	3.72E-04	8.56E-02	1.94E-03	6.72E-01	1.07E-01	1.90E-01
Gadwall	1.92E-03	6.23E+00	4.91E-03	6.74E-01	1.20E-04	2.53E+00
Golden plover	2.02E-03	6.23E+00	4.98E-03	6.74E-01	1.20E-04	2.53E+00
Great crested grebe	1.92E-03	6.23E+00	4.91E-03	6.74E-01	1.20E-04	2.53E+00

Table A3.3 *Continued*

Feature organism	^{137}Cs	^{210}Po	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Great crested newt	1.82E-03	6.23E+00	4.90E-03	6.74E-01	5.93E+00	2.53E+00
Grey plover	2.02E-03	6.23E+00	4.98E-03	6.74E-01	1.20E-04	2.53E+00
Hen harrier (female)	1.92E-03	6.23E+00	4.90E-03	6.74E-01	1.19E-04	2.53E+00
Hen harrier (male)	1.78E-03	6.23E+00	4.85E-03	6.74E-01	1.19E-04	2.53E+00
Knot	2.02E-03	6.23E+00	4.98E-03	6.74E-01	1.20E-04	2.53E+00
Lapwing	2.02E-03	6.23E+00	4.98E-03	6.74E-01	1.20E-04	2.53E+00
Large benthic crustacean	1.54E-04	6.23E+00	3.12E-04	1.86E-02	8.13E-03	6.34E-03
Lesser black-backed gull (female)	1.81E-03	6.23E+00	4.89E-03	6.74E-01	1.21E-04	2.53E+00
Lesser black-backed gull (male)	1.95E-03	6.23E+00	4.94E-03	6.74E-01	1.22E-04	2.53E+00
Macrophyte	3.72E-04	8.56E-02	1.94E-03	6.72E-01	1.07E-01	1.90E-01
Marsh harrier	1.92E-03	6.23E+00	4.90E-03	6.74E-01	1.19E-04	2.53E+00
Mediterranean gull	1.79E-03	6.23E+00	4.86E-03	6.74E-01	1.20E-04	2.53E+00
Natterjack toad	1.82E-03	6.23E+00	4.90E-03	6.74E-01	5.93E+00	2.53E+00
Otter (male and female)	2.00E-03	6.23E+00	4.97E-03	6.74E-01	1.34E-02	2.53E+00
Oystercatcher	1.95E-03	6.23E+00	4.94E-03	6.74E-01	1.22E-04	2.53E+00
Pelagic fish	1.96E-03	3.06E-03	1.12E-04	1.04E-03	4.11E-03	1.91E-03
Phytoplankton	5.45E-07	3.67E-01	3.99E-06	4.13E-04	1.07E-02	2.53E+00
Pink-footed goose	2.02E-03	6.23E+00	4.98E-03	6.74E-01	1.20E-04	2.53E+00
Pintail	1.92E-03	6.23E+00	4.91E-03	6.74E-01	1.20E-04	2.53E+00
Redshank	1.81E-03	6.23E+00	4.89E-03	6.74E-01	1.21E-04	2.53E+00
Ringed plover	1.81E-03	6.23E+00	4.89E-03	6.74E-01	1.21E-04	2.53E+00
River lamprey	1.67E-03	3.06E-03	1.98E-04	1.04E-03	4.11E-03	1.91E-03
Ruff	2.02E-03	6.23E+00	4.98E-03	6.74E-01	1.20E-04	2.53E+00
Sanderling	2.02E-03	6.23E+00	4.98E-03	6.74E-01	1.20E-04	2.53E+00
Scaup	1.99E-03	6.23E+00	4.96E-03	6.74E-01	1.19E-04	2.53E+00
Sea lamprey	2.03E-03	3.06E-03	1.03E-04	1.04E-03	4.11E-03	1.91E-03
Shelduck (female)	1.92E-03	6.23E+00	4.91E-03	6.74E-01	1.20E-04	2.53E+00
Shelduck (male)	1.99E-03	6.23E+00	4.96E-03	6.74E-01	1.19E-04	2.53E+00

Table A3.3 *Continued*

Feature organism	^{137}Cs	^{210}Po	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Small benthic crustacean	5.87E-04	3.12E-01	7.29E-04	9.64E-04	4.15E-04	3.37E-04
Snipe	2.01E-03	3.12E-01	4.97E-03	3.68E-02	7.49E-06	1.28E-01
Southern damselfly	1.50E-03	3.12E-01	3.79E-03	3.59E-02	2.97E-01	1.28E-01
Spined loach	1.77E-03	1.53E-04	5.63E-05	5.66E-05	2.06E-04	9.72E-05
Teal (female)	1.79E-03	3.12E-01	4.84E-03	3.68E-02	7.00E-06	1.28E-01
Teal (male)	1.92E-03	3.12E-01	4.90E-03	3.68E-02	7.22E-06	1.28E-01
Tufted duck (female)	1.92E-03	3.12E-01	4.90E-03	3.68E-02	7.22E-06	1.28E-01
Tufted duck (male)	1.99E-03	3.12E-01	4.94E-03	3.68E-02	6.60E-06	1.28E-01
Turnstone	1.81E-03	3.12E-01	4.88E-03	3.68E-02	8.42E-06	1.28E-01
Twaite shad	1.98E-03	1.53E-04	5.53E-05	5.67E-05	2.06E-04	9.71E-05
White-fronted goose	2.01E-03	3.12E-01	4.97E-03	3.68E-02	7.49E-06	1.28E-01
Whooper swan	1.99E-03	3.12E-01	4.94E-03	3.68E-02	6.60E-06	1.28E-01
Wigeon	1.92E-03	3.12E-01	4.90E-03	3.68E-02	7.22E-06	1.28E-01
Zooplankton	2.33E-06	1.83E-02	3.33E-04	5.70E-06	5.94E-05	1.28E-03

Table A3.4 *(Unweighted total) DPUC for freshwater spreadsheet - all radionuclides/species (μGy h^{-1} Bq^{-1} m^{-3})*

Feature organism	^{3}H	^{14}C	^{32}P	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}I	^{129}I	^{131}I
Allis shad	3.28E-09	1.31E-04	1.95E-02	1.93E-04	2.73E-05	2.63E-06	8.16E-06	9.50E-07	1.74E-06	5.70E-06
Amphibian	3.28E-09	2.08E-04	1.93E-02	2.21E-03	7.46E-04	7.57E-05	7.36E-03	1.14E-05	2.44E-05	7.54E-05
Aquatic mammal	3.28E-09	2.08E-04	1.77E-02	7.68E-04	6.68E-04	7.55E-05	5.75E-03	9.40E-06	2.34E-05	6.97E-05
Atlantic salmon	3.28E-09	1.31E-04	1.95E-02	1.93E-04	2.73E-05	2.63E-06	8.16E-06	9.50E-07	1.74E-06	5.70E-06
Avocet	3.28E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.14E-05	2.44E-05	7.51E-05
Bacteria	3.28E-09	2.28E-05	8.02E-03	3.00E-03	2.61E-04	1.52E-07	3.80E-05	1.63E-07	2.34E-07	1.52E-06
Bar-tailed godwit	3.28E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.14E-05	2.44E-05	7.51E-05
Benthic fish	3.28E-09	1.31E-04	1.94E-02	1.23E-03	3.20E-05	2.63E-06	1.09E-05	8.05E-07	1.67E-06	5.73E-06
Benthic mollusc	3.28E-09	2.07E-04	1.58E-02	1.57E-03	1.54E-04	1.38E-06	3.83E-03	2.33E-06	6.43E-06	1.89E-05
Bewicks swan	3.28E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.25E-05
Bittern	3.28E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.25E-05
Black-tailed godwit	3.28E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.14E-05	2.44E-05	7.51E-05
Brent goose	3.28E-09	2.08E-04	1.94E-02	1.89E-03	7.51E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.98E-05
Brook lamprey	3.28E-09	1.31E-04	1.96E-02	1.22E-03	3.12E-05	2.63E-06	1.08E-05	9.63E-07	1.75E-06	5.90E-06
Bullhead	3.28E-09	1.31E-04	1.93E-02	1.27E-03	3.30E-05	2.63E-06	1.10E-05	7.94E-07	1.65E-06	5.43E-06
Common scoter	3.28E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.25E-05
Cormorant	3.28E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.25E-05
Curlew	3.28E-09	2.08E-04	1.94E-02	1.89E-03	7.51E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.98E-05
Desmoulins whorl snail	3.28E-09	2.07E-04	1.49E-02	4.26E-04	1.21E-04	1.38E-06	3.82E-03	2.30E-06	6.42E-06	1.86E-05
Duck	3.28E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.25E-05
Dunlin	3.28E-09	2.08E-04	1.95E-02	1.31E-03	7.55E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.25E-05
Early gentian	3.28E-09	1.26E-04	6.80E-03	2.95E-03	4.23E-04	6.82E-05	1.12E-03	4.89E-06	1.45E-05	3.55E-05
Fen orchid	3.28E-09	1.26E-04	6.80E-03	2.95E-03	4.23E-04	6.82E-05	1.12E-03	4.89E-06	1.45E-05	3.55E-05
Gadwall	3.28E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.97E-05
Golden plover	3.28E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.26E-05

Table A3.4 *Continued*

Feature organism	^{3}H	^{14}C	^{32}P	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}I	^{129}I	^{131}I
Great crested grebe	3.28E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.97E-05
Great crested newt	3.28E-09	2.08E-04	1.93E-02	1.80E-03	7.44E-04	7.57E-05	7.36E-03	1.14E-05	2.44E-05	7.52E-05
Grey plover	3.28E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.26E-05
Hen harrier (female)	3.28E-09	2.08E-04	1.93E-02	1.24E-03	7.48E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.97E-05
Hen harrier (male)	3.28E-09	2.08E-04	1.92E-02	9.85E-04	7.40E-04	7.57E-05	7.35E-03	1.14E-05	2.44E-05	7.50E-05
Knot	3.28E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.26E-05
Lapwing	3.28E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.26E-05
Large benthic crustacean	3.28E-09	2.07E-04	1.67E-02	1.58E-03	1.63E-04	7.22E-07	4.53E-03	2.39E-06	6.47E-06	1.95E-05
Lesser black-backed gull (female)	3.28E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.14E-05	2.44E-05	7.51E-05
Lesser black-backed gull (male)	3.28E-09	2.08E-04	1.94E-02	1.89E-03	7.51E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.98E-05
Macrophyte	3.28E-09	1.26E-04	6.80E-03	2.95E-03	4.23E-04	6.82E-05	1.12E-03	4.88E-06	1.45E-05	3.54E-05
Marsh harrier	3.28E-09	2.08E-04	1.93E-02	1.24E-03	7.48E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.97E-05
Mediterranean gull	3.28E-09	2.08E-04	1.92E-02	1.12E-03	7.40E-04	7.57E-05	7.35E-03	1.14E-05	2.44E-05	7.50E-05
Natterjack toad	3.28E-09	2.08E-04	1.93E-02	1.80E-03	7.44E-04	7.57E-05	7.36E-03	1.14E-05	2.44E-05	7.52E-05
Otter (male and female)	3.28E-09	2.08E-04	1.95E-02	1.70E-03	7.56E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.26E-05
Oystercatcher	3.28E-09	2.08E-04	1.94E-02	1.89E-03	7.51E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.98E-05
Pelagic fish	3.28E-09	1.31E-04	1.94E-02	1.23E-03	3.20E-05	2.63E-06	1.09E-05	8.05E-07	1.67E-06	5.73E-06
Phytoplankton	3.28E-09	3.75E-07	4.86E-07	1.71E-06	6.57E-07	5.93E-08	5.77E-06	6.03E-07	4.18E-07	3.56E-07
Pink-footed goose	3.28E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.26E-05
Pintail	3.28E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.97E-05
Redshank	3.28E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.14E-05	2.44E-05	7.51E-05
Ringed plover	3.28E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.14E-05	2.44E-05	7.51E-05
River lamprey	3.28E-09	1.31E-04	1.81E-02	1.29E-03	4.15E-05	2.62E-06	1.24E-05	6.68E-07	1.58E-06	5.09E-06
Ruff	3.28E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.26E-05
Sanderling	3.28E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.26E-05
Scaup	3.28E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.25E-05
Sea lamprey	3.28E-09	1.31E-04	1.96E-02	1.22E-03	3.12E-05	2.63E-06	1.08E-05	9.63E-07	1.75E-06	5.90E-06
Shelduck (female)	3.28E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.97E-05

Table A3.4 *Continued*

Feature organism	^{3}H	^{14}C	^{32}P	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}I	^{129}I	^{131}I
Shelduck (male)	3.28E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.25E-05
Shoveler	3.28E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.97E-05
Small benthic crustacean	3.28E-09	2.02E-04	9.39E-03	1.56E-03	1.45E-04	6.71E-07	1.24E-03	2.05E-06	6.18E-06	1.57E-05
Snipe	3.28E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.26E-05
Southern damselfly	3.28E-09	2.07E-04	1.55E-02	1.35E-03	5.67E-04	7.48E-05	3.82E-03	8.08E-06	2.26E-05	6.55E-05
Spined loach	3.28E-09	1.31E-04	1.91E-02	1.80E-04	2.70E-05	2.63E-06	7.94E-06	7.77E-07	1.64E-06	5.22E-06
Teal (female)	3.28E-09	2.08E-04	1.92E-02	1.12E-03	7.40E-04	7.57E-05	7.35E-03	1.14E-05	2.44E-05	7.50E-05
Teal (male)	3.28E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.97E-05
Tufted duck (female)	3.28E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.97E-05
Tufted duck (male)	3.28E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.25E-05
Turnstone	3.28E-09	2.08E-04	1.92E-02	1.66E-03	7.43E-04	7.57E-05	7.35E-03	1.14E-05	2.44E-05	7.51E-05
Twaite shad	3.28E-09	1.31E-04	1.95E-02	1.93E-04	2.73E-05	2.63E-06	8.16E-06	9.50E-07	1.74E-06	5.70E-06
White-fronted goose	3.28E-09	2.08E-04	1.96E-02	1.95E-03	7.57E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.26E-05
Whooper swan	3.28E-09	2.08E-04	1.95E-02	1.44E-03	7.55E-04	7.59E-05	7.67E-03	1.41E-05	2.59E-05	8.25E-05
Wigeon	3.28E-09	2.08E-04	1.94E-02	1.37E-03	7.49E-04	7.58E-05	7.55E-03	1.16E-05	2.47E-05	7.97E-05
Zooplankton	3.28E-09	1.10E-04	2.69E-04	2.33E-05	4.81E-06	1.07E-06	7.39E-04	7.07E-06	2.17E-05	5.30E-05

Table A3.4 *Continued*

Feature organism	^{137}Cs	^{210}Po	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Allis shad	1.98E-03	1.53E-04	5.53E-05	5.67E-05	2.06E-04	9.71E-05
Amphibian	1.83E-03	3.12E-01	4.91E-03	3.68E-02	2.97E-01	1.28E-01
Aquatic mammal	1.62E-03	3.12E-01	4.40E-03	3.65E-02	6.72E-04	1.28E-01
Atlantic salmon	1.98E-03	1.53E-04	5.53E-05	5.67E-05	2.06E-04	9.71E-05
Avocet	1.81E-03	3.12E-01	4.88E-03	3.68E-02	8.42E-06	1.28E-01
Bacteria	1.88E-04	3.30E-03	2.09E-03	1.17E-04	1.19E-01	6.42E-03
Bar-tailed godwit	1.81E-03	3.12E-01	4.88E-03	3.68E-02	8.42E-06	1.28E-01
Benthic fish	1.95E-03	1.53E-04	1.11E-04	5.69E-05	2.10E-04	1.08E-04
Benthic mollusc	1.45E-04	3.12E-01	3.69E-04	9.97E-04	2.44E-03	3.36E-04
Bewicks swan	1.99E-03	3.12E-01	4.94E-03	3.68E-02	6.60E-06	1.28E-01
Bittern	1.99E-03	3.12E-01	4.94E-03	3.68E-02	6.60E-06	1.28E-01
Black-tailed godwit	1.81E-03	3.12E-01	4.88E-03	3.68E-02	8.42E-06	1.28E-01
Brent goose	1.94E-03	3.12E-01	4.93E-03	3.68E-02	8.92E-06	1.28E-01
Brook lamprey	2.02E-03	1.53E-04	1.03E-04	5.69E-05	2.08E-04	1.06E-04
Bullhead	1.82E-03	1.53E-04	1.21E-04	5.69E-05	2.09E-04	1.08E-04
Common scoter	1.99E-03	3.12E-01	4.94E-03	3.68E-02	6.60E-06	1.28E-01
Cormorant	1.99E-03	3.12E-01	4.94E-03	3.68E-02	6.60E-06	1.28E-01
Curlew	1.94E-03	3.12E-01	4.93E-03	3.68E-02	8.92E-06	1.28E-01
Desmoulins whorl snail	9.11E-05	3.12E-01	1.02E-04	9.95E-04	2.44E-03	3.22E-04
Duck	1.99E-03	3.12E-01	4.94E-03	3.68E-02	6.60E-06	1.28E-01
Dunlin	1.98E-03	3.12E-01	4.94E-03	3.68E-02	6.38E-06	1.28E-01
Early gentian	3.71E-04	4.28E-03	1.94E-03	3.46E-02	5.36E-03	9.61E-03
Fen orchid	3.71E-04	4.28E-03	1.94E-03	3.46E-02	5.36E-03	9.61E-03
Gadwall	1.92E-03	3.12E-01	4.90E-03	3.68E-02	7.22E-06	1.28E-01
Golden plover	2.01E-03	3.12E-01	4.97E-03	3.68E-02	7.49E-06	1.28E-01
Great crested grebe	1.92E-03	3.12E-01	4.90E-03	3.68E-02	7.22E-06	1.28E-01
Great crested newt	1.82E-03	3.12E-01	4.88E-03	3.68E-02	2.97E-01	1.28E-01

Table A3.4 *Continued*

Feature organism	^{137}Cs	^{210}Po	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Grey plover	2.01E-03	3.12E-01	4.97E-03	3.68E-02	7.49E-06	1.28E-01
Hen harrier (female)	1.91E-03	3.12E-01	4.89E-03	3.68E-02	6.79E-06	1.28E-01
Hen harrier (male)	1.78E-03	3.12E-01	4.83E-03	3.68E-02	6.65E-06	1.28E-01
Knot	2.01E-03	3.12E-01	4.97E-03	3.68E-02	7.49E-06	1.28E-01
Lapwing	2.01E-03	3.12E-01	4.97E-03	3.68E-02	7.49E-06	1.28E-01
Large benthic crustacean	1.53E-04	3.12E-01	3.12E-04	1.00E-03	4.13E-04	3.36E-04
Lesser black-backed gull (female)	1.81E-03	3.12E-01	4.88E-03	3.68E-02	8.42E-06	1.28E-01
Lesser black-backed gull (male)	1.94E-03	3.12E-01	4.93E-03	3.68E-02	8.92E-06	1.28E-01
Macrophyte	3.70E-04	4.28E-03	1.94E-03	3.46E-02	5.36E-03	9.61E-03
Marsh harrier	1.91E-03	3.12E-01	4.89E-03	3.68E-02	6.79E-06	1.28E-01
Mediterranean gull	1.79E-03	3.12E-01	4.84E-03	3.68E-02	7.00E-06	1.28E-01
Natterjack toad	1.82E-03	3.12E-01	4.88E-03	3.68E-02	2.97E-01	1.28E-01
Otter (male and female)	2.00E-03	3.12E-01	4.95E-03	3.68E-02	6.72E-04	1.28E-01
Oystercatcher	1.94E-03	3.12E-01	4.93E-03	3.68E-02	8.92E-06	1.28E-01
Pelagic fish	1.95E-03	1.53E-04	1.11E-04	5.69E-05	2.10E-04	1.08E-04
Phytoplankton	5.08E-07	1.83E-02	2.60E-06	2.12E-05	5.34E-04	1.26E-01
Pink-footed goose	2.01E-03	3.12E-01	4.97E-03	3.68E-02	7.49E-06	1.28E-01
Pintail	1.92E-03	3.12E-01	4.90E-03	3.68E-02	7.22E-06	1.28E-01
Redshank	1.81E-03	3.12E-01	4.88E-03	3.68E-02	8.42E-06	1.28E-01
Ringed plover	1.81E-03	3.12E-01	4.88E-03	3.68E-02	8.42E-06	1.28E-01
River lamprey	1.67E-03	1.53E-04	1.98E-04	5.69E-05	2.10E-04	1.10E-04
Ruff	2.01E-03	3.12E-01	4.97E-03	3.68E-02	7.49E-06	1.28E-01
Sanderling	2.01E-03	3.12E-01	4.97E-03	3.68E-02	7.49E-06	1.28E-01
Scaup	1.99E-03	3.12E-01	4.94E-03	3.68E-02	6.60E-06	1.28E-01
Sea lamprey	2.02E-03	1.53E-04	1.03E-04	5.69E-05	2.08E-04	1.06E-04
Shelduck (female)	1.92E-03	3.12E-01	4.90E-03	3.68E-02	7.22E-06	1.28E-01
Shelduck (male)	1.99E-03	3.12E-01	4.94E-03	3.68E-02	6.60E-06	1.28E-01
Shoveler	1.92E-03	3.12E-01	4.90E-03	3.68E-02	7.22E-06	1.28E-01

Table A3.4 *Continued*

Feature organism	^{137}Cs	^{210}Po	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Small benthic crustacean	5.87E-04	3.12E-01	7.29E-04	9.64E-04	4.15E-04	3.37E-04
Snipe	2.01E-03	3.12E-01	4.97E-03	3.68E-02	7.49E-06	1.28E-01
Southern damselfly	1.50E-03	3.12E-01	3.79E-03	3.59E-02	2.97E-01	1.28E-01
Spined loach	1.77E-03	1.53E-04	5.63E-05	5.66E-05	2.06E-04	9.72E-05
Teal (female)	1.79E-03	3.12E-01	4.84E-03	3.68E-02	7.00E-06	1.28E-01
Teal (male)	1.92E-03	3.12E-01	4.90E-03	3.68E-02	7.22E-06	1.28E-01
Tufted duck (female)	1.92E-03	3.12E-01	4.90E-03	3.68E-02	7.22E-06	1.28E-01
Tufted duck (male)	1.99E-03	3.12E-01	4.94E-03	3.68E-02	6.60E-06	1.28E-01
Turnstone	1.81E-03	3.12E-01	4.88E-03	3.68E-02	8.42E-06	1.28E-01
Twaite shad	1.98E-03	1.53E-04	5.53E-05	5.67E-05	2.06E-04	9.71E-05
White-fronted goose	2.01E-03	3.12E-01	4.97E-03	3.68E-02	7.49E-06	1.28E-01
Whooper swan	1.99E-03	3.12E-01	4.94E-03	3.68E-02	6.60E-06	1.28E-01
Wigeon	1.92E-03	3.12E-01	4.90E-03	3.68E-02	7.22E-06	1.28E-01
Zooplankton	2.33E-06	1.83E-02	3.33E-04	5.70E-06	5.94E-05	1.28E-03

Table A3.5 *(Weighted total) DPUC for terrestrial spreadsheet - all radionuclides/species (μGy h^{-1} Bq^{-1} m^{-3} for ^{3}H, ^{14}C, ^{32}P, ^{41}Ar and ^{85}Kr and (μGy h^{-1} Bq^{-1} kg^{-1} for all other radionuclides)*

Feature organism	^{3}H	^{14}C	^{32}P	^{35}S	^{41}Ar	^{85}Kr	^{60}Co	^{90}Sr	^{106}Ru	^{129}I
Ant	1.57E-03	8.68E-03	3.54E-01	1.40E-03	2.51E-04	1.06E-05	6.82E-04	1.43E-03	3.73E-04	5.23E-05
Bacteria	5.27E-04	5.36E-02	7.54E-01	1.41E-03	1.01E-07	1.46E-08	1.05E-03	4.57E-04	6.55E-04	4.20E-05
Bechsteins bat	1.36E-03	1.97E-02	2.57E-01	1.41E-03	6.15E-04	4.07E-06	1.98E-04	2.83E-03	9.37E-04	4.93E-05
Bee	1.50E-03	1.20E-02	1.60E-01	1.40E-03	6.05E-04	6.68E-06	1.62E-04	2.47E-03	5.61E-05	4.84E-05
Bewicks swan	1.32E-03	2.01E-02	2.79E-01	1.41E-03	3.37E-04	8.95E-07	4.11E-04	3.18E-03	1.22E-03	5.22E-05
Bird	1.32E-03	2.01E-02	2.81E-01	1.41E-03	4.16E-04	1.12E-06	4.48E-04	3.17E-03	1.20E-03	5.40E-05
Bird egg	1.50E-03	8.06E-03	1.41E-01	1.41E-03	3.07E-04	2.03E-06	5.67E-04	2.85E-03	1.02E-03	5.24E-05
Black-tailed godwit	1.32E-03	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	5.33E-05
Brent goose	1.32E-03	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	5.33E-05
Carnivorous mammal	1.36E-03	1.97E-02	2.81E-01	1.41E-03	1.56E-04	4.13E-07	8.23E-04	3.19E-03	1.26E-03	5.53E-05
Caterpillar	1.49E-03	1.20E-02	1.45E-01	1.40E-03	6.58E-04	1.19E-05	1.26E-04	2.08E-03	5.37E-05	4.77E-05
Chough	1.32E-03	2.01E-02	2.79E-01	1.41E-03	3.37E-04	8.95E-07	4.11E-04	3.18E-03	1.22E-03	5.22E-05
Curlew	1.32E-03	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	5.33E-05
Dartford warbler	1.32E-03	2.01E-02	2.80E-01	1.41E-03	4.26E-04	1.61E-06	4.35E-04	3.08E-03	1.13E-03	5.30E-05
Desmoulins whorl snail	1.49E-03	1.21E-02	1.91E-01	1.40E-03	4.93E-04	8.90E-06	3.14E-04	2.11E-03	1.32E-04	4.95E-05
Dormouse	1.36E-03	1.97E-02	2.97E-01	1.41E-03	2.46E-04	1.63E-06	6.78E-04	2.86E-03	1.05E-03	5.33E-05
Dunlin	1.32E-03	2.01E-02	2.81E-01	1.41E-03	4.16E-04	1.12E-06	4.48E-04	3.17E-03	1.20E-03	5.40E-05
Early gentian	1.16E-03	1.74E-02	6.25E-01	4.14E-03	3.69E-04	1.93E-05	1.08E-03	1.35E-03	7.77E-04	5.62E-05
Earthworm	1.48E-03	1.03E-02	3.34E-01	1.41E-03	7.87E-08	1.38E-09	1.06E-03	2.25E-03	9.31E-04	5.60E-05
Fen orchid	1.16E-03	1.74E-02	6.25E-01	4.14E-03	3.69E-04	1.93E-05	1.08E-03	1.35E-03	7.77E-04	5.62E-05
Fungi	2.11E-03	6.77E-02	9.22E-01	2.91E-03	4.20E-04	6.07E-05	1.18E-03	4.88E-04	1.40E-03	9.11E-05
Gadwall	1.32E-03	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	5.23E-05
Golden plover	1.32E-03	2.01E-02	2.82E-01	1.41E-03	2.41E-04	6.68E-07	5.19E-04	3.16E-03	1.20E-03	5.31E-05
Great crested newt	1.32E-03	2.01E-02	2.88E-01	1.41E-03	2.55E-04	9.69E-07	6.53E-04	3.08E-03	1.17E-03	5.45E-05

Table A3.5 *Continued*

Feature organism	^{3}H	^{14}C	^{32}P	^{35}S	^{41}Ar	^{85}Kr	^{60}Co	^{90}Sr	^{106}Ru	^{129}I
Greater horseshoe bat	1.36E-03	1.97E-02	2.57E-01	1.41E-03	6.15E-04	4.07E-06	1.98E-04	2.83E-03	9.37E-04	4.93E-05
Grey plover	1.32E-03	2.01E-02	2.82E-01	1.41E-03	2.41E-04	6.68E-07	5.19E-04	3.16E-03	1.20E-03	5.31E-05
Hen harrier (male and female)	1.32E-03	2.01E-02	2.80E-01	1.41E-03	4.26E-04	1.61E-06	4.35E-04	3.08E-03	1.13E-03	5.30E-05
Herb	1.16E-03	1.74E-02	6.25E-01	4.14E-03	3.69E-04	1.93E-05	1.08E-03	1.35E-03	7.77E-04	5.62E-05
Herbivorous mammal	1.32E-03	2.14E-02	3.07E-01	1.41E-03	1.34E-04	3.71E-07	8.56E-04	3.17E-03	1.25E-03	5.56E-05
Honey buzzard	1.32E-03	2.01E-02	2.80E-01	1.41E-03	4.26E-04	1.61E-06	4.35E-04	3.08E-03	1.13E-03	5.30E-05
Kittewake	1.32E-03	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	5.23E-05
Knot	1.32E-03	2.01E-02	2.82E-01	1.41E-03	2.41E-04	6.68E-07	5.19E-04	3.16E-03	1.20E-03	5.31E-05
Lapwing	1.32E-03	2.01E-02	2.82E-01	1.41E-03	2.34E-04	6.19E-07	5.38E-04	3.18E-03	1.23E-03	5.32E-05
Lesser black-backed gull (male and female)	1.32E-03	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	5.33E-05
Lesser horseshoe bat	1.36E-03	1.97E-02	2.57E-01	1.41E-03	6.15E-04	4.07E-06	1.98E-04	2.83E-03	9.37E-04	4.93E-05
Lichen	1.58E-03	1.40E-03	1.68E-01	4.18E-03	3.38E-04	8.64E-06	5.54E-04	1.87E-03	6.29E-04	5.10E-05
Marsh harrier	1.32E-03	2.01E-02	2.80E-01	1.41E-03	4.26E-04	1.61E-06	4.35E-04	3.08E-03	1.13E-03	5.30E-05
Mediterranean gull	1.32E-03	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	5.23E-05
Natterjack toad	1.32E-03	2.01E-02	2.88E-01	1.41E-03	2.55E-04	9.69E-07	6.53E-04	3.08E-03	1.17E-03	5.45E-05
Nightjar	1.32E-03	2.01E-02	2.77E-01	1.41E-03	4.61E-04	3.05E-06	3.83E-04	2.84E-03	9.80E-04	5.08E-05
Otter (male and female)	1.36E-03	1.97E-02	2.82E-01	1.41E-03	1.30E-04	3.44E-07	8.65E-04	3.19E-03	1.27E-03	5.57E-05
Oystercatcher	1.32E-03	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	5.33E-05
Peregrine	1.32E-03	2.01E-02	2.81E-01	1.41E-03	4.16E-04	1.12E-06	4.48E-04	3.17E-03	1.20E-03	5.40E-05
Petal wort	1.16E-03	1.74E-02	6.25E-01	4.14E-03	3.69E-04	1.93E-05	1.08E-03	1.35E-03	7.77E-04	5.62E-05
Pink-footed goose	1.32E-03	2.01E-02	2.82E-01	1.41E-03	2.34E-04	6.19E-07	5.38E-04	3.18E-03	1.23E-03	5.32E-05
Pintail	1.32E-03	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	5.23E-05
Redshank	1.32E-03	2.01E-02	2.81E-01	1.41E-03	2.77E-04	1.83E-06	4.32E-04	2.84E-03	9.92E-04	5.13E-05
Reptile	1.32E-03	2.01E-02	2.93E-01	1.41E-03	1.70E-04	6.46E-07	8.03E-04	3.09E-03	1.19E-03	5.55E-05
Ringed plover	1.32E-03	2.01E-02	2.81E-01	1.41E-03	2.77E-04	1.83E-06	4.32E-04	2.84E-03	9.92E-04	5.13E-05
Rodent	1.36E-03	1.97E-02	3.16E-01	1.41E-03	1.23E-04	8.93E-07	8.62E-04	2.83E-03	1.07E-03	5.48E-05
Ruff	1.32E-03	2.01E-02	2.82E-01	1.41E-03	2.41E-04	6.68E-07	5.19E-04	3.16E-03	1.20E-03	5.31E-05
Sand lizard	1.32E-03	2.01E-02	2.90E-01	1.41E-03	2.27E-04	8.61E-07	6.99E-04	3.08E-03	1.18E-03	5.48E-05

Table A3.5 *Continued*

Feature organism	^{3}H	^{14}C	^{32}P	^{35}S	^{41}Ar	^{85}Kr	^{60}Co	^{90}Sr	^{106}Ru	^{129}I
Sanderling	1.32E-03	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	5.33E-05
Seed	8.87E-05	1.30E-01	9.63E-01	1.42E-03	3.92E-04	3.17E-05	1.08E-03	9.86E-04	7.31E-04	5.59E-05
Shore dock	1.16E-03	1.74E-02	6.25E-01	4.14E-03	3.69E-04	1.93E-05	1.08E-03	1.35E-03	7.77E-04	5.62E-05
Short-eared owl	1.32E-03	2.01E-02	2.81E-01	1.41E-03	4.01E-04	1.11E-06	4.75E-04	3.16E-03	1.20E-03	5.28E-05
Shoveler	1.32E-03	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	5.23E-05
Shrub	1.49E-03	1.35E-02	6.07E-01	4.14E-03	3.69E-04	1.93E-05	1.08E-03	3.38E-04	7.77E-04	5.62E-05
Smooth snake	1.32E-03	2.01E-02	2.90E-01	1.41E-03	2.27E-04	8.61E-07	6.99E-04	3.08E-03	1.18E-03	5.48E-05
Snipe	1.32E-03	2.01E-02	2.82E-01	1.41E-03	2.41E-04	6.68E-07	5.19E-04	3.16E-03	1.20E-03	5.31E-05
Stag beetle	1.41E-03	1.60E-02	2.48E-01	1.41E-03	2.78E-04	2.01E-06	6.16E-04	2.81E-03	1.01E-03	5.27E-05
Stone curlew	1.32E-03	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	5.33E-05
Teal	1.32E-03	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	5.23E-05
Tree	1.05E-03	3.64E-02	7.09E-01	4.14E-03	3.69E-04	1.93E-05	1.12E-03	5.45E-04	7.77E-04	5.62E-05
White-fronted goose	1.32E-03	2.01E-02	2.82E-01	1.41E-03	2.50E-04	6.69E-07	4.93E-04	3.17E-03	1.21E-03	5.42E-05
Whooper swan	1.32E-03	2.01E-02	2.79E-01	1.41E-03	3.37E-04	8.95E-07	4.11E-04	3.18E-03	1.22E-03	5.22E-05
Wigeon	1.32E-03	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	5.23E-05
Woodlark	1.32E-03	2.01E-02	2.80E-01	1.41E-03	4.26E-04	1.61E-06	4.35E-04	3.08E-03	1.13E-03	5.30E-05
Woodlouse	1.41E-03	1.62E-02	2.94E-01	1.40E-03	3.43E-04	1.01E-05	5.52E-04	1.78E-03	6.09E-04	5.08E-05

Table A3.5 *Continued*

Feature organism	^{131}I	^{137}Cs	^{226}Ra	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Ant	2.05E-04	1.74E-04	3.73E-01	1.59E-04	7.25E-02	8.13E-04	8.94E-04
Bacteria	2.31E-04	3.28E-04	2.38E-01	3.67E-04	7.26E-02	4.15E-02	4.43E-02
Bechsteins bat	1.35E-04	1.37E-03	3.72E-01	1.13E-05	7.25E-02	4.15E-02	4.43E-02
Bee	1.35E-04	3.79E-05	3.72E-01	1.91E-05	7.25E-02	1.13E-04	1.35E-04
Bewicks swan	1.84E-04	3.68E-04	2.05E-02	8.47E-06	7.26E-02	4.15E-02	4.43E-02
Bird	1.79E-04	3.53E-04	2.06E-02	1.07E-05	7.26E-02	4.15E-02	4.43E-02
Bird egg	1.91E-04	1.45E-03	3.73E-01	3.17E-05	7.26E-02	4.15E-02	4.43E-02
Black-tailed godwit	1.82E-04	3.52E-04	2.07E-02	1.51E-05	7.26E-02	4.15E-02	4.43E-02
Brent goose	1.82E-04	3.52E-04	2.07E-02	1.51E-05	7.26E-02	4.15E-02	4.43E-02
Carnivorous mammal	2.42E-04	1.99E-03	3.73E-01	1.64E-05	7.26E-02	4.15E-02	4.43E-02
Caterpillar	1.26E-04	1.20E-03	3.72E-01	2.05E-05	7.25E-02	4.15E-02	4.43E-02
Chough	1.84E-04	3.68E-04	2.05E-02	8.47E-06	7.26E-02	4.15E-02	4.43E-02
Curlew	1.82E-04	3.52E-04	2.07E-02	1.51E-05	7.26E-02	4.15E-02	4.43E-02
Dartford warbler	1.75E-04	3.42E-04	2.06E-02	1.37E-05	7.26E-02	4.15E-02	4.43E-02
Desmoulins whorl snail	1.55E-04	1.24E-03	3.72E-01	4.62E-05	7.25E-02	4.15E-02	4.43E-02
Dormouse	2.08E-04	1.39E-04	8.44E-03	3.79E-05	2.41E-04	2.97E-05	2.34E-05
Dunlin	1.79E-04	3.53E-04	2.06E-02	1.07E-05	7.26E-02	4.15E-02	4.43E-02
Early gentian	2.68E-04	2.91E-04	6.67E-02	2.76E-04	4.83E-04	1.19E-04	2.01E-05
Earthworm	2.63E-04	2.39E-04	3.73E-01	1.38E-04	7.26E-02	1.54E-03	1.28E-03
Fen orchid	2.68E-04	2.91E-04	6.67E-02	2.76E-04	4.83E-04	1.19E-04	2.01E-05
Fungi	3.56E-04	4.88E-04	6.10E-01	3.94E-04	1.45E-01	8.30E-02	8.85E-02
Gadwall	1.62E-04	3.21E-04	2.05E-02	1.09E-05	7.26E-02	4.15E-02	4.43E-02
Golden plover	1.92E-04	3.77E-04	2.07E-02	1.19E-05	7.26E-02	4.15E-02	4.43E-02
Great crested newt	2.08E-04	1.68E-03	3.73E-01	2.05E-05	7.26E-02	4.15E-02	4.43E-02
Greater horseshoe bat	1.35E-04	1.37E-03	3.72E-01	1.13E-05	7.25E-02	4.15E-02	4.43E-02
Grey plover	1.92E-04	3.77E-04	2.07E-02	1.19E-05	7.26E-02	4.15E-02	4.43E-02
Hen harrier (male and female)	1.75E-04	3.42E-04	2.06E-02	1.37E-05	7.26E-02	4.15E-02	4.43E-02

Table A3.5 *Continued*

Feature organism	^{131}I	^{137}Cs	^{226}Ra	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Herb	2.68E-04	2.91E-04	6.67E-02	2.76E-04	4.83E-04	1.19E-04	2.01E-05
Herbivorous mammal	2.42E-04	5.59E-04	3.73E-01	1.45E-05	4.30E-04	6.05E-06	1.61E-05
Honey buzzard	1.75E-04	3.42E-04	2.06E-02	1.37E-05	7.26E-02	4.15E-02	4.43E-02
Kittewake	1.62E-04	3.21E-04	2.05E-02	1.09E-05	7.26E-02	4.15E-02	4.43E-02
Knot	1.92E-04	3.77E-04	2.07E-02	1.19E-05	7.26E-02	4.15E-02	4.43E-02
Lapwing	2.02E-04	3.96E-04	2.07E-02	1.09E-05	7.26E-02	4.15E-02	4.43E-02
Lesser black-backed gull (male and female)	1.82E-04	3.52E-04	2.07E-02	1.51E-05	7.26E-02	4.15E-02	4.43E-02
Lesser horseshoe bat	1.35E-04	1.37E-03	3.72E-01	1.13E-05	7.25E-02	4.15E-02	4.43E-02
Lichen	1.82E-04	2.16E-04	3.44E-02	8.84E-05	7.25E-02	3.91E-02	4.43E-02
Marsh harrier	1.75E-04	3.42E-04	2.06E-02	1.37E-05	7.26E-02	4.15E-02	4.43E-02
Mediterranean gull	1.62E-04	3.21E-04	2.05E-02	1.09E-05	7.26E-02	4.15E-02	4.43E-02
Natterjack toad	2.08E-04	1.68E-03	3.73E-01	2.05E-05	7.26E-02	4.15E-02	4.43E-02
Nightjar	1.63E-04	3.08E-04	2.06E-02	2.15E-05	7.25E-02	4.15E-02	4.43E-02
Otter (male and female)	2.48E-04	2.00E-03	3.73E-01	1.72E-05	7.26E-02	4.15E-02	4.43E-02
Oystercatcher	1.82E-04	3.52E-04	2.07E-02	1.51E-05	7.26E-02	4.15E-02	4.43E-02
Peregrine	1.79E-04	3.53E-04	2.06E-02	1.07E-05	7.26E-02	4.15E-02	4.43E-02
Petal wort	2.68E-04	2.91E-04	6.67E-02	2.76E-04	4.83E-04	1.19E-04	2.01E-05
Pink-footed goose	2.02E-04	3.96E-04	2.07E-02	1.09E-05	7.26E-02	4.15E-02	4.43E-02
Pintail	1.62E-04	3.21E-04	2.05E-02	1.09E-05	7.26E-02	4.15E-02	4.43E-02
Redshank	1.70E-04	3.19E-04	2.07E-02	2.42E-05	7.26E-02	4.15E-02	4.43E-02
Reptile	2.31E-04	1.71E-03	3.73E-01	2.51E-05	7.26E-02	4.15E-02	4.43E-02
Ringed plover	1.70E-04	3.19E-04	2.07E-02	2.42E-05	7.26E-02	4.15E-02	4.43E-02
Rodent	2.36E-04	1.82E-04	8.66E-03	5.24E-05	2.56E-04	2.98E-05	2.57E-05
Ruff	1.92E-04	3.77E-04	2.07E-02	1.19E-05	7.26E-02	4.15E-02	4.43E-02
Sand lizard	2.15E-04	1.69E-03	3.73E-01	2.19E-05	7.26E-02	4.15E-02	4.43E-02
Sanderling	1.82E-04	3.52E-04	2.07E-02	1.51E-05	7.26E-02	4.15E-02	4.43E-02
Seed	2.63E-04	9.37E-04	3.73E-01	3.24E-04	7.26E-02	4.15E-02	2.06E-05
Shore dock	2.68E-04	2.91E-04	6.67E-02	2.76E-04	4.83E-04	1.19E-04	2.01E-05

Table A3.5 *Continued*

Feature organism	^{131}I	^{137}Cs	^{226}Ra	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Short-eared owl	1.86E-04	3.67E-04	2.06E-02	1.10E-05	7.26E-02	4.15E-02	4.43E-02
Shoveler	1.62E-04	3.21E-04	2.05E-02	1.09E-05	7.26E-02	4.15E-02	4.43E-02
Shrub	2.68E-04	2.93E-04	7.58E-02	2.76E-04	4.83E-04	1.19E-04	2.01E-05
Smooth snake	2.15E-04	1.69E-03	3.73E-01	2.19E-05	7.26E-02	4.15E-02	4.43E-02
Snipe	1.92E-04	3.77E-04	2.07E-02	1.19E-05	7.26E-02	4.15E-02	4.43E-02
Stag beetle	1.98E-04	1.29E-04	3.73E-01	3.74E-05	7.26E-02	2.67E-03	2.35E-03
Stone curlew	1.82E-04	3.52E-04	2.07E-02	1.51E-05	7.26E-02	4.15E-02	4.43E-02
Teal	1.62E-04	3.21E-04	2.05E-02	1.09E-05	7.26E-02	4.15E-02	4.43E-02
Tree	2.68E-04	2.81E-04	3.87E-02	2.76E-04	1.47E-02	2.19E-02	9.50E-03
White-fronted goose	1.86E-04	3.63E-04	2.07E-02	1.17E-05	7.26E-02	4.15E-02	4.43E-02
Whooper swan	1.84E-04	3.68E-04	2.05E-02	8.47E-06	7.26E-02	4.15E-02	4.43E-02
Wigeon	1.62E-04	3.21E-04	2.05E-02	1.09E-05	7.26E-02	4.15E-02	4.43E-02
Woodlark	1.75E-04	3.42E-04	2.06E-02	1.37E-05	7.26E-02	4.15E-02	4.43E-02
Woodlouse	1.80E-04	1.27E-04	3.73E-01	9.37E-05	7.25E-02	2.67E-03	2.35E-03

Table A3.6 *(Unweighted total) DPUC for terrestrial spreadsheet - all radionuclides/species (μGy h^{-1} Bq^{-1} m^{-3} for ^{3}H, ^{14}C, ^{32}P, ^{41}Ar and ^{85}Kr and (μGy h^{-1} Bq^{-1} kg^{-1} for all other radionuclides)*

Feature organism	^{3}H	^{14}C	^{32}P	^{35}S	^{41}Ar	^{85}Kr	^{60}Co	^{90}Sr	^{106}Ru	^{129}I
Ant	5.24E-04	8.68E-03	3.54E-01	1.40E-03	2.51E-04	1.06E-05	6.82E-04	1.43E-03	3.73E-04	4.33E-05
Bacteria	1.76E-04	5.36E-02	7.54E-01	1.41E-03	1.01E-07	1.46E-08	1.05E-03	4.57E-04	6.55E-04	3.57E-05
Bechsteins bat	4.52E-04	1.97E-02	2.57E-01	1.41E-03	6.15E-04	4.07E-06	1.98E-04	2.83E-03	9.37E-04	4.03E-05
Bee	4.98E-04	1.20E-02	1.60E-01	1.40E-03	6.05E-04	6.68E-06	1.62E-04	2.47E-03	5.61E-05	3.94E-05
Bewicks swan	4.39E-04	2.01E-02	2.79E-01	1.41E-03	3.37E-04	8.95E-07	4.11E-04	3.18E-03	1.22E-03	4.32E-05
Bird	4.39E-04	2.01E-02	2.81E-01	1.41E-03	4.16E-04	1.12E-06	4.48E-04	3.17E-03	1.20E-03	4.49E-05
Bird egg	4.98E-04	8.06E-03	1.41E-01	1.41E-03	3.07E-04	2.03E-06	5.67E-04	2.85E-03	1.02E-03	4.34E-05
Black-tailed godwit	4.39E-04	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	4.43E-05
Brent goose	4.39E-04	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	4.43E-05
Carnivorous mammal	4.53E-04	1.97E-02	2.81E-01	1.41E-03	1.56E-04	4.13E-07	8.23E-04	3.19E-03	1.26E-03	4.63E-05
Caterpillar	4.98E-04	1.20E-02	1.45E-01	1.40E-03	6.58E-04	1.19E-05	1.26E-04	2.08E-03	5.37E-05	3.86E-05
Chough	4.39E-04	2.01E-02	2.79E-01	1.41E-03	3.37E-04	8.95E-07	4.11E-04	3.18E-03	1.22E-03	4.32E-05
Curlew	4.39E-04	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	4.43E-05
Dartford warbler	4.39E-04	2.01E-02	2.80E-01	1.41E-03	4.26E-04	1.61E-06	4.35E-04	3.08E-03	1.13E-03	4.39E-05
Desmoulins whorl snail	4.98E-04	1.21E-02	1.91E-01	1.40E-03	4.93E-04	8.90E-06	3.14E-04	2.11E-03	1.32E-04	4.04E-05
Dormouse	4.52E-04	1.97E-02	2.97E-01	1.41E-03	2.46E-04	1.63E-06	6.78E-04	2.86E-03	1.05E-03	4.43E-05
Dunlin	4.39E-04	2.01E-02	2.81E-01	1.41E-03	4.16E-04	1.12E-06	4.48E-04	3.17E-03	1.20E-03	4.49E-05
Early gentian	3.87E-04	1.74E-02	6.25E-01	4.14E-03	3.69E-04	1.93E-05	1.08E-03	1.35E-03	7.77E-04	4.72E-05
Earthworm	4.92E-04	1.03E-02	3.34E-01	1.41E-03	7.87E-08	1.38E-09	1.06E-03	2.25E-03	9.31E-04	4.69E-05
Fen orchid	3.87E-04	1.74E-02	6.25E-01	4.14E-03	3.69E-04	1.93E-05	1.08E-03	1.35E-03	7.77E-04	4.72E-05
Fungi	7.02E-04	6.77E-02	9.22E-01	2.91E-03	4.20E-04	6.07E-05	1.18E-03	4.88E-04	1.40E-03	7.58E-05
Gadwall	4.39E-04	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	4.33E-05
Golden plover	4.39E-04	2.01E-02	2.82E-01	1.41E-03	2.41E-04	6.68E-07	5.19E-04	3.16E-03	1.20E-03	4.41E-05
Great crested newt	4.39E-04	2.01E-02	2.88E-01	1.41E-03	2.55E-04	9.69E-07	6.53E-04	3.08E-03	1.17E-03	4.54E-05

Table A3.6 *Continued*

Feature organism	^{3}H	^{14}C	^{32}P	^{35}S	^{41}Ar	^{85}Kr	^{60}Co	^{90}Sr	^{106}Ru	^{129}I
Greater horseshoe bat	4.52E-04	1.97E-02	2.57E-01	1.41E-03	6.15E-04	4.07E-06	1.98E-04	2.83E-03	9.37E-04	4.03E-05
Grey plover	4.39E-04	2.01E-02	2.82E-01	1.41E-03	2.41E-04	6.68E-07	5.19E-04	3.16E-03	1.20E-03	4.41E-05
Hen harrier (male and female)	4.39E-04	2.01E-02	2.80E-01	1.41E-03	4.26E-04	1.61E-06	4.35E-04	3.08E-03	1.13E-03	4.39E-05
Herb	3.87E-04	1.74E-02	6.25E-01	4.14E-03	3.69E-04	1.93E-05	1.08E-03	1.35E-03	7.77E-04	4.72E-05
Herbivorous mammal	4.39E-04	2.14E-02	3.07E-01	1.41E-03	1.34E-04	3.71E-07	8.56E-04	3.17E-03	1.25E-03	4.66E-05
Honey buzzard	4.39E-04	2.01E-02	2.80E-01	1.41E-03	4.26E-04	1.61E-06	4.35E-04	3.08E-03	1.13E-03	4.39E-05
Kittewake	4.39E-04	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	4.33E-05
Knot	4.39E-04	2.01E-02	2.82E-01	1.41E-03	2.41E-04	6.68E-07	5.19E-04	3.16E-03	1.20E-03	4.41E-05
Lapwing	4.39E-04	2.01E-02	2.82E-01	1.41E-03	2.34E-04	6.19E-07	5.38E-04	3.18E-03	1.23E-03	4.41E-05
Lesser black-backed gull (male and female)	4.39E-04	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	4.43E-05
Lesser horseshoe bat	4.52E-04	1.97E-02	2.57E-01	1.41E-03	6.15E-04	4.07E-06	1.98E-04	2.83E-03	9.37E-04	4.03E-05
Lichen	5.28E-04	1.40E-03	1.68E-01	4.18E-03	3.38E-04	8.64E-06	5.54E-04	1.87E-03	6.29E-04	4.19E-05
Marsh harrier	4.39E-04	2.01E-02	2.80E-01	1.41E-03	4.26E-04	1.61E-06	4.35E-04	3.08E-03	1.13E-03	4.39E-05
Mediterranean gull	4.39E-04	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	4.33E-05
Natterjack toad	4.39E-04	2.01E-02	2.88E-01	1.41E-03	2.55E-04	9.69E-07	6.53E-04	3.08E-03	1.17E-03	4.54E-05
Nightjar	4.39E-04	2.01E-02	2.77E-01	1.41E-03	4.61E-04	3.05E-06	3.83E-04	2.84E-03	9.80E-04	4.18E-05
Otter (male and female)	4.53E-04	1.97E-02	2.82E-01	1.41E-03	1.30E-04	3.44E-07	8.65E-04	3.19E-03	1.27E-03	4.66E-05
Oystercatcher	4.39E-04	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	4.43E-05
Peregrine	4.39E-04	2.01E-02	2.81E-01	1.41E-03	4.16E-04	1.12E-06	4.48E-04	3.17E-03	1.20E-03	4.49E-05
Petal wort	3.87E-04	1.74E-02	6.25E-01	4.14E-03	3.69E-04	1.93E-05	1.08E-03	1.35E-03	7.77E-04	4.72E-05
Pink-footed goose	4.39E-04	2.01E-02	2.82E-01	1.41E-03	2.34E-04	6.19E-07	5.38E-04	3.18E-03	1.23E-03	4.41E-05
Pintail	4.39E-04	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	4.33E-05
Redshank	4.39E-04	2.01E-02	2.81E-01	1.41E-03	2.77E-04	1.83E-06	4.32E-04	2.84E-03	9.92E-04	4.22E-05
Reptile	4.39E-04	2.01E-02	2.93E-01	1.41E-03	1.70E-04	6.46E-07	8.03E-04	3.09E-03	1.19E-03	4.65E-05
Ringed plover	4.39E-04	2.01E-02	2.81E-01	1.41E-03	2.77E-04	1.83E-06	4.32E-04	2.84E-03	9.92E-04	4.22E-05
Rodent	4.52E-04	1.97E-02	3.16E-01	1.41E-03	1.23E-04	8.93E-07	8.62E-04	2.83E-03	1.07E-03	4.57E-05
Ruff	4.39E-04	2.01E-02	2.82E-01	1.41E-03	2.41E-04	6.68E-07	5.19E-04	3.16E-03	1.20E-03	4.41E-05
Sand lizard	4.39E-04	2.01E-02	2.90E-01	1.41E-03	2.27E-04	8.61E-07	6.99E-04	3.08E-03	1.18E-03	4.58E-05

Table A3.6 *Continued*

Feature organism	^{3}H	^{14}C	^{32}P	^{35}S	^{41}Ar	^{85}Kr	^{60}Co	^{90}Sr	^{106}Ru	^{129}I
Sanderling	4.39E-04	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	4.43E-05
Seed	2.96E-05	1.30E-01	9.63E-01	1.42E-03	3.92E-04	3.17E-05	1.08E-03	9.86E-04	7.31E-04	4.69E-05
Shore dock	3.87E-04	1.74E-02	6.25E-01	4.14E-03	3.69E-04	1.93E-05	1.08E-03	1.35E-03	7.77E-04	4.72E-05
Short-eared owl	4.39E-04	2.01E-02	2.81E-01	1.41E-03	4.01E-04	1.11E-06	4.75E-04	3.16E-03	1.20E-03	4.38E-05
Shoveler	4.39E-04	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	4.33E-05
Shrub	4.98E-04	1.35E-02	6.07E-01	4.14E-03	3.69E-04	1.93E-05	1.08E-03	3.38E-04	7.77E-04	4.72E-05
Smooth snake	4.39E-04	2.01E-02	2.90E-01	1.41E-03	2.27E-04	8.61E-07	6.99E-04	3.08E-03	1.18E-03	4.58E-05
Snipe	4.39E-04	2.01E-02	2.82E-01	1.41E-03	2.41E-04	6.68E-07	5.19E-04	3.16E-03	1.20E-03	4.41E-05
Stag beetle	4.69E-04	1.60E-02	2.48E-01	1.41E-03	2.78E-04	2.01E-06	6.16E-04	2.81E-03	1.01E-03	4.37E-05
Stone curlew	4.39E-04	2.01E-02	2.81E-01	1.41E-03	2.55E-04	9.69E-07	4.81E-04	3.08E-03	1.14E-03	4.43E-05
Teal	4.39E-04	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	4.33E-05
Tree	3.51E-04	3.64E-02	7.09E-01	4.14E-03	3.69E-04	1.93E-05	1.12E-03	5.45E-04	7.77E-04	4.72E-05
White-fronted goose	4.39E-04	2.01E-02	2.82E-01	1.41E-03	2.50E-04	6.69E-07	4.93E-04	3.17E-03	1.21E-03	4.52E-05
Whooper swan	4.39E-04	2.01E-02	2.79E-01	1.41E-03	3.37E-04	8.95E-07	4.11E-04	3.18E-03	1.22E-03	4.32E-05
Wigeon	4.39E-04	2.01E-02	2.76E-01	1.41E-03	3.69E-04	1.40E-06	3.43E-04	3.07E-03	1.12E-03	4.33E-05
Woodlark	4.39E-04	2.01E-02	2.80E-01	1.41E-03	4.26E-04	1.61E-06	4.35E-04	3.08E-03	1.13E-03	4.39E-05
Woodlouse	4.69E-04	1.62E-02	2.94E-01	1.40E-03	3.43E-04	1.01E-05	5.52E-04	1.78E-03	6.09E-04	4.18E-05

Table A3.6 *Continued*

Feature organism	^{137}Cs	^{226}Ra	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Ant	1.74E-04	2.00E-02	1.59E-04	3.91E-03	4.09E-05	5.32E-05
Bacteria	3.28E-04	1.35E-02	3.66E-04	3.99E-03	2.08E-03	2.25E-03
Bechsteins bat	1.36E-03	1.97E-02	1.13E-05	3.94E-03	2.08E-03	2.24E-03
Bee	3.79E-05	1.96E-02	1.91E-05	3.91E-03	5.67E-06	8.55E-06
Bewicks swan	3.68E-04	1.28E-03	8.45E-06	3.97E-03	2.08E-03	2.24E-03
Bird	3.53E-04	1.37E-03	1.07E-05	3.97E-03	2.08E-03	2.24E-03
Bird egg	1.45E-03	2.01E-02	3.17E-05	3.96E-03	2.08E-03	2.24E-03
Black-tailed godwit	3.52E-04	1.43E-03	1.51E-05	3.97E-03	2.08E-03	2.24E-03
Brent goose	3.52E-04	1.43E-03	1.51E-05	3.97E-03	2.08E-03	2.24E-03
Carnivorous mammal	1.98E-03	2.04E-02	1.64E-05	3.98E-03	2.08E-03	2.24E-03
Caterpillar	1.19E-03	1.95E-02	2.04E-05	3.87E-03	2.08E-03	2.24E-03
Chough	3.68E-04	1.28E-03	8.45E-06	3.97E-03	2.08E-03	2.24E-03
Curlew	3.52E-04	1.43E-03	1.51E-05	3.97E-03	2.08E-03	2.24E-03
Dartford warbler	3.41E-04	1.38E-03	1.37E-05	3.97E-03	2.08E-03	2.24E-03
Desmoulins whorl snail	1.24E-03	1.97E-02	4.62E-05	3.89E-03	2.08E-03	2.24E-03
Dormouse	1.39E-04	1.07E-03	3.79E-05	4.50E-05	1.57E-06	7.16E-06
Dunlin	3.53E-04	1.37E-03	1.07E-05	3.97E-03	2.08E-03	2.24E-03
Early gentian	2.91E-04	4.84E-03	2.76E-04	2.87E-04	6.25E-06	1.41E-05
Earthworm	2.39E-04	2.06E-02	1.38E-04	3.99E-03	7.74E-05	7.58E-05
Fen orchid	2.91E-04	4.84E-03	2.76E-04	2.87E-04	6.25E-06	1.41E-05
Fungi	4.87E-04	3.31E-02	3.93E-04	7.91E-03	4.16E-03	4.48E-03
Gadwall	3.21E-04	1.28E-03	1.09E-05	3.96E-03	2.08E-03	2.24E-03
Golden plover	3.76E-04	1.42E-03	1.19E-05	3.97E-03	2.08E-03	2.24E-03
Great crested newt	1.67E-03	2.03E-02	2.05E-05	3.97E-03	2.08E-03	2.24E-03
Greater horseshoe bat	1.36E-03	1.97E-02	1.13E-05	3.94E-03	2.08E-03	2.24E-03
Grey plover	3.76E-04	1.42E-03	1.19E-05	3.97E-03	2.08E-03	2.24E-03
Hen harrier (male and female)	3.41E-04	1.38E-03	1.37E-05	3.97E-03	2.08E-03	2.24E-03

Table A3.6 *Continued*

Feature organism	^{137}Cs	^{226}Ra	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Herb	2.91E-04	4.84E-03	2.76E-04	2.87E-04	6.25E-06	1.41E-05
Herbivorous mammal	5.58E-04	2.05E-02	1.45E-05	3.76E-05	4.14E-07	7.11E-06
Honey buzzard	3.41E-04	1.38E-03	1.37E-05	3.97E-03	2.08E-03	2.24E-03
Kittewake	3.21E-04	1.28E-03	1.09E-05	3.96E-03	2.08E-03	2.24E-03
Knot	3.76E-04	1.42E-03	1.19E-05	3.97E-03	2.08E-03	2.24E-03
Lapwing	3.95E-04	1.42E-03	1.09E-05	3.98E-03	2.08E-03	2.24E-03
Lesser black-backed gull (male and female)	3.52E-04	1.43E-03	1.51E-05	3.97E-03	2.08E-03	2.24E-03
Lesser horseshoe bat	1.36E-03	1.97E-02	1.13E-05	3.94E-03	2.08E-03	2.24E-03
Lichen	2.15E-04	2.39E-03	8.84E-05	3.90E-03	1.96E-03	2.24E-03
Marsh harrier	3.41E-04	1.38E-03	1.37E-05	3.97E-03	2.08E-03	2.24E-03
Mediterranean gull	3.21E-04	1.28E-03	1.09E-05	3.96E-03	2.08E-03	2.24E-03
Natterjack toad	1.67E-03	2.03E-02	2.05E-05	3.97E-03	2.08E-03	2.24E-03
Nightjar	3.07E-04	1.40E-03	2.15E-05	3.95E-03	2.08E-03	2.24E-03
Otter (male and female)	1.99E-03	2.05E-02	1.72E-05	3.98E-03	2.08E-03	2.24E-03
Oystercatcher	3.52E-04	1.43E-03	1.51E-05	3.97E-03	2.08E-03	2.24E-03
Peregrine	3.53E-04	1.37E-03	1.07E-05	3.97E-03	2.08E-03	2.24E-03
Petal wort	2.91E-04	4.84E-03	2.76E-04	2.87E-04	6.25E-06	1.41E-05
Pink-footed goose	3.95E-04	1.42E-03	1.09E-05	3.98E-03	2.08E-03	2.24E-03
Pintail	3.21E-04	1.28E-03	1.09E-05	3.96E-03	2.08E-03	2.24E-03
Redshank	3.18E-04	1.46E-03	2.42E-05	3.95E-03	2.08E-03	2.24E-03
Reptile	1.71E-03	2.04E-02	2.51E-05	3.98E-03	2.08E-03	2.24E-03
Ringed plover	3.18E-04	1.46E-03	2.42E-05	3.95E-03	2.08E-03	2.24E-03
Rodent	1.82E-04	1.29E-03	5.24E-05	5.98E-05	1.61E-06	9.44E-06
Ruff	3.76E-04	1.42E-03	1.19E-05	3.97E-03	2.08E-03	2.24E-03
Sand lizard	1.68E-03	2.03E-02	2.19E-05	3.98E-03	2.08E-03	2.24E-03
Sanderling	3.52E-04	1.43E-03	1.51E-05	3.97E-03	2.08E-03	2.24E-03
Seed	9.32E-04	2.05E-02	3.24E-04	4.01E-03	2.08E-03	1.46E-05
Shore dock	2.91E-04	4.84E-03	2.76E-04	2.87E-04	6.25E-06	1.41E-05

Table A3.6 *Continued*

Feature organism	^{137}Cs	^{226}Ra	^{234}Th	^{238}U	^{239}Pu	^{241}Am
Short-eared owl	3.66E-04	1.38E-03	1.10E-05	3.97E-03	2.08E-03	2.24E-03
Shoveler	3.21E-04	1.28E-03	1.09E-05	3.96E-03	2.08E-03	2.24E-03
Shrub	2.93E-04	5.31E-03	2.76E-04	2.87E-04	6.25E-06	1.41E-05
Smooth snake	1.68E-03	2.03E-02	2.19E-05	3.98E-03	2.08E-03	2.24E-03
Snipe	3.76E-04	1.42E-03	1.19E-05	3.97E-03	2.08E-03	2.24E-03
Stag beetle	1.29E-04	2.01E-02	3.74E-05	3.96E-03	1.34E-04	1.24E-04
Stone curlew	3.52E-04	1.43E-03	1.51E-05	3.97E-03	2.08E-03	2.24E-03
Teal	3.21E-04	1.28E-03	1.09E-05	3.96E-03	2.08E-03	2.24E-03
Tree	2.81E-04	3.41E-03	2.76E-04	1.02E-03	1.10E-03	4.92E-04
White-fronted goose	3.63E-04	1.42E-03	1.17E-05	3.97E-03	2.08E-03	2.24E-03
Whooper swan	3.68E-04	1.28E-03	8.45E-06	3.97E-03	2.08E-03	2.24E-03
Wigeon	3.21E-04	1.28E-03	1.09E-05	3.96E-03	2.08E-03	2.24E-03
Woodlark	3.41E-04	1.38E-03	1.37E-05	3.97E-03	2.08E-03	2.24E-03
Woodlouse	1.27E-04	1.99E-02	9.37E-05	3.90E-03	1.34E-04	1.24E-04

Glossary

The following definitions are a guide for the reader and are not legally binding.

Authorisations

Environmental licence issued by the Environment Agency for the disposal of radioactive waste from premises or from mobile radioactive apparatus and for accumulation of any radioactive waste with a view to its subsequent disposal (see sections 13 and 14 Under RSA 93).

Component species

A component species is defined, for the purposes of this report, as a species identified with a feature habitat that may require protection or could be used to demonstrate adequate protection to a habitat but that is not listed in EA (2002).

Concentration factor

The ratio between the concentration in the medium and the concentration in the organism.

Consents

Under the Water Resources Act 1991(as amended by the Environment Act 1995) the Environment Agency may give an operator the right to discharge substances (water, sewage, etc) into surface water, subject to certain conditions.

Dose per Unit Concentration (DPUC)

Internal: Absorbed dose averaged over the volume of the organism per unit concentration of the radionuclide contained within the organism's tissues (assuming uniform distribution throughout the organism). In this report the dose is also expressed as a dose rate.
External: Absorbed dose averaged over the volume of the organism per unit concentration of the radionuclide in the medium surrounding the organism. The organism is assumed to be immersed in a uniformly contaminated medium of infinite extent.

Environmental licence

An environmental licence is (under EPA 95, Part 1 (56)) in the application of this Part in relation to the Agency, means any of the following:

(a) registration of a person as a carrier of controlled waste under section 2 of the [1989 c. 14.] Control of Pollution (Amendment) Act 1989,
(b) an authorisation under Part I of the 1990 Act, other than any such authorisation granted by a local enforcing authority,
(c) a waste management licence under Part II of that Act,
(d) a licence under Chapter II of Part II of the 1991Act (i.e. Water Resources Act),
(e) a consent for the purposes of section 88(1)(a), 89(4)(a) or 90 of that Act,
(f) registration under the [1993 c. 12.] Radioactive Substances Act 1993,
(g) an authorisation under that Act,
(h) registration of a person as a broker of controlled waste under the [S.I. 1994/1056.] Waste Management Licensing Regulations 1994,
(j) registration in respect of an activity falling within paragraph 45(1) or (2) of Schedule 3 to those Regulations, so far as having effect in relation to England and Wales.

Feature species

A named species that has been identified as requiring protection in EA (2002) (Habitats Directive: Habitats and species protected under the Habitats and Birds Directives), Environment Agency's EU Habitats and Birds Directives Handbook for Agency Permissions and Activities.

Feature Habitat

A named habitat that has been identified as requiring protection in EA (2002) (Habitats Directive: Habitats and species protected under the Habitats and Birds Directives), Environment Agency's EU Habitats and Birds Directives Handbook for Agency Permissions and Activities

Habitat
The place in which a plant or animal lives.

Habitats Directive
The abbreviated term of *Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora.* It is the aim of this Directive to promote the conservation of certain habitats and species within the European Union.

Interest feature
A natural or semi-natural feature for which a European site has been selected. This includes any Habitats Directive Annex I habitat, or any Annex II species and any population of a bird species for which a SPA has been designated under the Birds Directive.

Licences
A formal permit allowing the holder to engage in an activity, subject to conditions specified in the licence itself and the legislation under which it is issued.

Natura 2000
The European network of protected sites established under the Birds Directive and the Habitats Directive.

National Nature Reserves (NNRs)
Sites of national importance declared under section 19 of the National Parks and Access to the Countryside Act 1949 or section 35 of the Wildlife and Countryside Act 1981 and managed primarily for nature conservation.

Occupancy factor
A measure of the time period that a specified organism spends in an identified ecosystem compartment of a named ecosystem as a fraction of the total time period that the organism spends in that ecosystem

Permissions
A certificate of registration, authorisation or variation notice issued by the Environment Agency.

Permits
A permit granted by the regulator allowing the operation of an Installation subject to certain conditions.

Ramsar Site
A site listed under the Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat 1971 as amended 1982.

Reference organism
A series of entities that provide a basis for the estimation of radiation dose rate to a range of organisms, which are typical, or representative, of a contaminated environment. These estimates, in turn, would provide a basis for assessing the likelihood and degree of radiation effects.

Sites of Special Scientific Interest (SSSIs)
Sites of national nature conservation interest notified under section 28 of the Wildlife and Countryside Act 1981.

Special Area of Conservation (SACs)
Areas of international importance designated, or to be designated, under the EC Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora to protect the habitats of threatened species of wildlife.

Special Protection Area (SPAs)
Areas of international importance classified under the EC Directive on the Conservation of Wild Birds to conserve the habitat of bird species listed in Annex I of the Directive.

Stage 1 Assessment
Identifying whether the Habitats Regulations are applicable to a given authorisation.

Stage 2 Assessment
Identifying whether authorisations to discharge radioactive substances present a potential risk of significant effect on wildlife and habitats.

Stage 3 Assessment
Identifying issues to consider when carrying out a more detailed assessment of the potential impact of radioactive discharges for sites identified as presenting a potential risk.

List of abbreviations

CF	Concentration Factor
DPUC	Dose (or dose rate) per Unit Concentration
EA	Environment Agency
EN	English Nature
FRED	FASSET Radiation Effects Database (see www.fasset.org)
JNCC	Joint Nature Conservation Committee
NGR	National Grid Reference
NNRs	National Nature Reserves
R&D	Research and Development
RSA	Radioactive Substances Authorisation
RSPB	Royal Society for the Protection of Birds
SAC/cSAC	Special Area of Conservation / Candidate Special Area of Conservation
SPA/cSPA	Special Protection Area / Candidate Special Protection Area
SSSI	Site of Special Scientific Interest

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