

**NDAWG**  
National Dose Assessment Working Group

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## **NDAWG GUIDANCE NOTE 7**

### **Use of Habits Data in Prospective Dose Assessments**

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#### **1 Introduction and purpose**

Prospective dose assessments are required to predict the radiological impacts of future authorised discharges of radionuclides to the environment and of the future direct irradiation of members of the public from facilities using, storing or discharging radioactive materials. These assessments relate either to ongoing authorised activities at a site or to the proposed introduction of new activities at a site, which will require an authorisation. Prospective dose assessments are usually made to cover five to 10 years of future operations and discharges similar to the timescales over which habits surveys are repeated.

Prospective dose assessments require a number of inputs of data, one of which is information and assumptions about the habits of people near the site. The habits data is used in the dose calculations from which the dose to the representative person can be determined.

The representative person is an individual receiving a dose that is representative of the more highly exposed individuals in the population. The representative person is the equivalent of and replaces the previous term 'average member of the critical group'.

The representative person may be exposed to all the discharges of radioactive waste and emissions of radiation from the site in combination. The habits data should therefore address all potential combinations of habits that may lead to exposure from each element of discharge and emissions separately and in combination.

Habits survey allows identification of the members of one or more exposed individuals or groups around the site and an assessment of their doses. These can be called 'candidates for the representative person'. An assessment may be made of the doses to each of the candidates for

the representative person and the candidate for the representative person receiving the highest dose is the representative person.

The habits data available are normally collected from site-specific habits surveys. Integrated site-specific habits surveys have been carried out by UK government bodies (Environment Agencies, Food Standards Agency and the Office for nuclear regulation) around nuclear sites in the UK over the last 10 years. They are designed to gather integrated habits data that can be used to determine the degree of exposure to atmospheric discharges, liquid discharges and direct radiation at the same time. The integrated data are now being used to make annual retrospective assessments of dose to the public around nuclear sites. The data are collated into profiles that allow a realistic assessment of doses to be made across a range of pathways affected by liquid discharges, gaseous discharges and direct radiation. The dose assessment outcomes are reported in the RIFE report series.

Prior to the integrated habits surveys, the habits data related to exposure to atmospheric discharges, liquid discharges and direct radiation were collected separately. Site specific surveys have also been used to determine the potential exposure to solid radioactive wastes, for example to determine potential exposure to radioactive fragments on beaches near Dounreay or Sellafield.

In addition, in the past, UK wide surveys were conducted which have been used to provide information on food consumption rates. The UK data gathered have been collated to provide generic food consumption data expressed as percentiles across a range of age groups [Ref 1].

Historically there were multiple methods for assessment of dose for prospective dose assessments which produced a variety of outputs. In some cases site-specific habits data were used and in some cases generalized habits data from UK surveys were used. Where site specific habits data were available, the data were used in a range of ways. The NDAWG habits subgroup compared all the methods of using the data and from this identified the most appropriate ways of making use of habits data collected around nuclear sites [Ref 2].

For non-nuclear sites, there is limited site-specific habits information collected and published. Where some site-specific habits data are available, retrospective and prospective dose assessments make use of whatever data are available combined with UK generalised habits data sets. For many sites however, UK Generalised Habits Data may be the only habits data available.

In recent years, prospective dose assessments have moved towards a two stage process. The first stage is made using an initial or screening approach. Examples are the Environment Agency initial assessment system [Refs 3 and 4] and the approach developed by HPA for small users [Ref 5]. Where doses from the screening assessment are predicted to be above the appropriate criteria a more detailed assessment may follow as a second stage. The assumptions about habits made in the screening tools can be factored into how habits data are used in the subsequent site-specific assessments.

## **2 Use of habits data in prospective dose assessments**

### **2.1 Issues**

There are three main issues for prospective dose assessments.

- i) They must provide an estimate of doses from future discharges such that the outcomes can be used in the optimisation process. Optimisation currently requires all exposures to be kept as low as reasonably achievable (ALARA), taking into account economic and social factors. For protecting members of the public where a discharge of radioactivity is being permitted, there is a requirement to use Best Available Techniques (BAT) to help ensure optimisation in England and Wales [Ref 6]. Application of BAT provides an indication that discharges and exposures have been reduced and that costs and benefits are considered to ensure that the cost of applying a technique is not disproportionate in relation to the protection it provides. In

Scotland and Northern Ireland, optimisation is achieved through the use of authorisation conditions requiring the application of Best Practicable Means (BPM). The Environment Agency and SEPA consider that the requirements to use BPM are equivalent to the requirements to use BAT and that the obligations on waste producers are the same.

It is important that the prospective dose assessment outcomes give a realistic assessment that can be applied in the optimisation process and provide an input to the BAT and BPM process, where appropriate. Therefore, the dose assessment outcomes should avoid both significant underestimates and significant overestimates of the dose otherwise optimisation may not be achieved.

- ii) They should be carried out in such a manner as to provide confidence that they have been carried out appropriately, covering all reasonably foreseeable situations and exposure routes using realistic information on habits and land use.
- iii) They need to be valid for a number of years (typically 5 to 10 years) into the future. It is not possible to predict what may happen in future that may influence habits and increase exposure. Therefore a degree of caution may need to be retained at some stages in the dose assessment process. Where doses are predicted to be greater than 20  $\mu\text{Sv}$  per year, a sensitivity analysis can be carried out to establish what factors are important and influence the validity of the assessment into the future.

## **2.2 Challenges**

The competing pressures of a realistic assessment of harm to inform the optimisation process and the need to consider reasonably foreseeable future situations mean that it can be difficult to create consistent and appropriate prospective dose assessments.

If an overestimate of doses is made but the outcome is a predicted annual effective dose below 20  $\mu\text{Sv}$  the outcome can be an input into the optimisation process, because the assessed dose is sufficiently low that it will not be a primary consideration in determining the optimum technique. The acceptability of an overestimation of dose (where a low dose outcome is produced) as an input to the optimisation process means that an initial assessment using simple and conservative modelling is a valid approach. This will also be a more efficient assessment process – reducing the need to undertake detailed and refined assessments where the predicted doses are low.

If an overestimate of dose is made and the outcome is a predicted annual effective dose  $>20 \mu\text{Sv}$ , it may lead to an inappropriate regulatory decision and a non-optimal outcome. This is more likely to occur where predicted annual effective doses approach or exceed 300  $\mu\text{Sv}$ . Where an initial assessment leads to an annual effective dose  $>20 \mu\text{Sv}$  there needs to be a mechanism to interpret the result and refine the assessment, if necessary, before inputting into the optimisation process. The refinement will normally be a more realistic prospective dose assessment either of critical exposure pathways or the entire assessment.

This guidance document identifies the most appropriate options for making use of habits data in prospective dose assessments, covering both initial assessments and refined realistic assessment of doses. The best options were selected from a full evaluation of the various ways that habits data have been used in prospective dose assessments to date together with some additional options. The evaluation was undertaken by an NDAWG working group and there is a full NDAWG report on the topic [Ref 2].

## **2.3 Habits data use in initial assessments**

The UK regulatory authorities (Environment Agency, Scottish Environment Protection Agency and Food Standards Agency) make use of a staged approach to assessments. This may use an initial assessment [for example Refs 3 and 4]. Initial assessments use generalised habits data [Ref 1] and a variety of simple and conservative modelling assumptions.

The HPA [Ref 1] has adopted generalised habits data in an assessment approach that is widely used by non-nuclear sites (small users). The HPA approach is similar to the Environment Agency initial assessment system.

Where an initial assessment followed by a refined assessment are undertaken, there will be two outcomes - which together provide a robust assessment of the impact of the discharges. The initial assessment will provide an outcome which because of its conservative element is strongly "future proofed" (see Appendix A) against changes in the exposure situation that could lead to a higher future dose. The refined assessment will provide a more realistic assessment which is appropriate for use to support optimisation of the authorisation or permit.

## 2.4 Use of habits data to make prospective assessments

This part of the guidance note indicates how habits data for prospective dose assessments should be best used in prospective assessments for optimisation (see also Figure 1). There are currently two main methods that can be used, when making a refined assessment after an initial assessment: the unadjusted profiling and the top two methods. The use of habits data under each of these options and the implications are shown in Table 1.

Details of all the methods and evaluations of their suitability are given in Appendix A.

**Table 1 Application of habits data and the implications**

Habits data application	Outcome
1) Initial radiological assessment. Uses UK generalised habits data with a strong overestimate of habit combinations.	Generates the most conservative assessment outcome (highest estimate of doses)
2) Refined initial radiological assessment. Uses improved specific information on dispersion and/or habits.	Generates a more refined (lower) estimate of doses than the initial assessment but will still be conservative.
3a) Site-specific assessment using unadjusted habits profiles. Site-specific habits data are available and have been collected using an integrated survey (considering all the habits related to liquid and gaseous discharges and direct radiation)	Generates the most realistic and lowest assessment of doses for the next 5-10 years.
3b) Site-specific assessment using the top two method, making use of generic UK-wide habits data. This method can be used where no site-specific habits data are available.	Generates a reasonably realistic assessment of doses for the next 5-10 years - which will be more conservative and give higher doses than using habits profiles.
Selecting the habits data used in the assessment for combining doses from different modes of discharge requires some care. There is the potential for introducing inconsistencies and inappropriate conservatism into the assessment.	
The top two habits data are often taken from the 97.5 <sup>th</sup> percentile of the distribution. The ICRP has indicated that it is appropriate to use the 95 <sup>th</sup> percentile.	
The assessments should consider appropriate age groups, which include infants (one year old), children (10 years old) and adults. In a few cases, the fetus/breast fed infant will also need to be considered, but the habits data are for the mother. Where site-specific information on habits by age group is limited, generic data may be used to augment the information.	

## 2.5 Other approaches to habits data in prospective dose assessments

One other common approach that has been used in the past and was evaluated is the 'individual' method. This method is described briefly and evaluated in Appendix A and in more detail in reference 2. It is a relatively complex method and was judged less suitable by NDAWG [Ref 2].

## **2.6 Other factors to consider in prospective dose assessments**

When making prospective assessments - there are a number of other factors to consider. These are the following.

- i) Age groups in addition to adult will need to be taken into account in dose assessments. Where insufficient site-specific habits data are available for non-adults, UK generic data can be used to augment the available information.
- ii) In some cases, such as assessment of discharges to sewage works, workers may receive the highest doses and they will always be adults. It will be acceptable to use data on occupancy based on assumptions about working patterns.
- iii) Key aspects of a prospective assessment should be fully documented, so that the assessment is transparent and can be reproduced by others. In particular, the habits adopted should be described in the documentation together with the sources of the habits data and any assumptions on how they are used in the assessment.
- iv) It may be necessary to consider unusual as well as standard exposure pathways and further guidance on this is given in the relevant NDAWG guidance note [Ref 7] and reports (see [www.ndawg.org](http://www.ndawg.org)).

## **2.7 Compliance with the principles document**

Compliance with the 2002 principles document for prospective radiological assessment [Ref 8] was assessed as part of the detailed evaluation of the habits options (see appendix A). The revised 2012 principles [Ref 9] which are similar to the 2002 principles are given in appendix B.

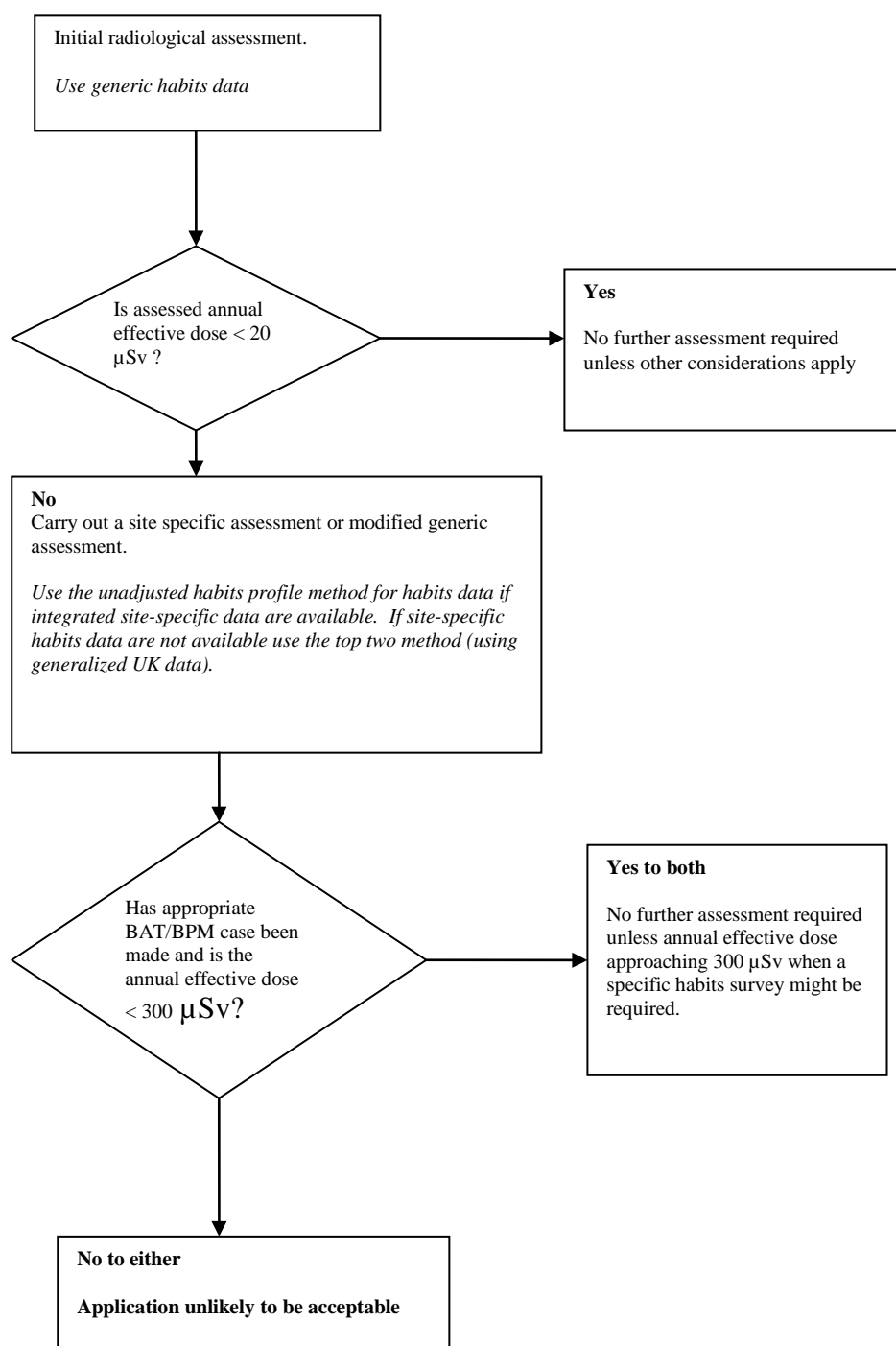
## **3 Summary of recommendations**

This guidance note recommends:

- a) Initial assessment of doses using an appropriate initial assessment system using conservative habits combinations. Where annual effective doses are less than  $<20 \mu\text{Sv}$  are predicted, the outcome can be used to assist the determination of a permit or authorisation. Refinement of the initial assessment when predicted annual effective doses from the initial assessment are  $>20 \mu\text{Sv}$ .
- b) Use of site-specific habits data as an input to production of a refined assessment where integrated habits data are available. The recommended approach for use of the site specific data is the creation of "habits data profiles" (see Appendix A for a definition). The outcome can be used to assist the determination of a permit or authorisation.
- c) Where site-specific habits data are not available, generalised UK habits data can be used. The recommended approach is "top two" (See Appendix A for a definition). Consideration will need to be given to habits combinations where exposure to more than one discharge route may occur (usually gaseous discharges and liquid discharges). The outcome can be used to assist the determination of a permit or authorisation.
- d) Age groups in addition to adult will need to be considered in the assessment. Where insufficient site-specific habits data are available for age groups, generalised UK habits data can be used to augment the information.

#### **4 References**

- [1] Smith KR and Jones AL (2003) Generalised habit data for radiological assessment. Chilton, NRPB-W41.
- [2] National Dose Assessment Working Group (2009). Acquisition and Use of Habits Data for Prospective Assessments. NDAWG/2/2009. Available at [www.ndawg.org](http://www.ndawg.org)
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- [6] Environment Agency (2010). Radioactive Substances Regulation – Environmental Principles. RSR1.
- [7] National Dose Assessment Working Group (2004). Radiological Assessment Exposure Pathways Checklist (Common and Unusual). NDAWG/2/2004. Available at [www.ndawg.org](http://www.ndawg.org)
- [8] Environment Agency, Scottish Environment Protection Agency, Department of Environment, Northern Ireland, National Radiological Protection Board, Food Standards Agency, (2002). Radioactive Substances Regulation - Authorisation of Discharges of Radioactive Waste to the Environment Principles for the Assessment of Prospective Public Doses Interim Guidance.
- [9] Environment Agency, Scottish Environment Protection Agency, Department of Environment, Northern Ireland, Health Protection Agency and Food Standards Agency, (2012). Principles for the Assessment of Prospective Public Doses arising from Authorised Discharges of Radioactive Waste to the Environment.



**Figure 1: The use of habits data in prospective radiological assessments**



## **Appendix A: Details of the recommended methods of using habits data in prospective assessments**

### **A1.1 Top two method using generalised UK data**

The assessment uses generalised data for the UK [Ref 1] as the basis. The assessment is initially made with all the relevant food intake rates set to high levels either using the 95<sup>th</sup> or 97.5<sup>th</sup> percentile. The assessment results identify the two food types that give rise to the highest doses ("top two"). Intake rates of these food types are retained at 'critical levels', whereas the other habits are reduced to 50<sup>th</sup> percentile levels and the assessment is repeated. Note that this implies that ingestion of contaminated foods is the principal determinant of the dose received. In some contexts, external exposure and inhalation may also make significant contributions. In such contexts, dose contributions from these pathways, at a location appropriate to the exposed individual, should be added to the dose contribution from ingestion of foods estimated using the top two method.

### **A1.2 Habits data profiling (unadjusted profiling)**

The habits survey data are obtained and tabulated by observation number (surveyed individual) and pathway.

For the first pathway, the observations are ordered by descending rate of consumption (for foodstuffs) or occupancy (for external exposure and inhalation). Observations for individuals who have consumption or occupancy rates between the maximum and one third of the maximum are identified and retained for the next step of the analysis. For this subset of observations, the mean rates for all pathways are calculated. These mean rates are adopted for the group associated with the first pathway, referred to as the pathway 1 profile, eg, if pathway 1 was fish consumption, this would be the fish consumption profile.

The process is then repeated for each of the other pathways to give as many profiles as there are pathways. The dose for each profile can then be calculated and the values compared. Examples of the application of this method are given in the NDAWG Report of the habits working group [Ref 2] on which this guidance note is based.

### **A1.3 Other methods**

One other common approach that had been used for a number of years was the 'individual' method. In the past, habits surveys were carried out considering terrestrial exposure and coastal exposure separately. This resulted in discrete data sets for terrestrial habits and marine/coastal habits. Two data sets were then created; one for all the coastal habits at sites on the coast and one for the onshore (terrestrial) pathways. For each individual in the habits data set for terrestrial pathways, annual effective doses from all terrestrial pathways were calculated. For each individual in the habits data sets from all coastal pathways annual effective doses were calculated. Then a total dose across the terrestrial and coastal exposures was calculated by summation. A distribution of annual effective doses was produced from the combined data set. The 97.5<sup>th</sup> percentile of this distribution was reported as the 'possible dose' and the median value as the 'probable dose'. This method scored less well in comparison with the profiles method and currently is not widely used.

Other methods for assessing doses from discharges to the marine environment included use of the mean consumption rates and occupancy rates between the top value and 1/3 of the top value looking at the different pathways separately. The habits of the critical group were the mean values for the different pathways.

The methods were evaluated relative to eight criteria as shown in Table A1 by the working group [see also Ref 2].



**Table A1 Evaluation of methods for using habits data**

Criteria	Approach						Normalised Weight
	EA Screen	NRPB W-63 screening	Top Two: Generic Data	Profile	Individual: Single Survey	Weight	
Transparency	5	5	4	4	2	1	0.125
Homogeneity	1	2	3	5	2	1	0.125
Realism	1	2	2	4	5	1	0.125
Robustness	3	3	3	5	4	1	0.125
Defensibility	2	2	3	4	5	1	0.125
Future Proof	5	5	5	3	3	1	0.125
Ease of Application	5	4	3	2	1	1	0.125
Compliance with Principles	2	2	2	4	4	1	0.125
Score	3.000	3.125	3.125	3.875	3.25	8	

#### A1.4 Description of the criteria used

**Transparency** is the ease with which the approach can be understood, and the degree to which there is a straightforward and readily perceived relationship between the habits data used and the results obtained. For example, a transparent assessment will allow the implications of a change in habits on the results to be readily estimated, either qualitatively (eg, whether changes in the results will occur and the direction of those changes) or semi-quantitatively.

**Homogeneity** is the degree to which the critical group adopted for assessment purposes is reasonably homogeneous with respect to habits and behaviour.

**Realism** addresses the issue of whether the habits of the group are closely related to those that are observed at the present day, or that might reasonably be expected to be observed over the period for which a prospective assessment might be carried out (typically about 5 years).

**Robustness** addresses whether the results of the assessment will remain broadly valid in the face of a range of changes in habits that could plausibly occur, but are not necessarily likely to occur, over the period for which a prospective assessment might be carried out.

**Defensibility** relates to whether the approach can be justified to interested parties – ie, is it internally coherent, does it conform to principles and assumptions commonly employed in other areas, and is the approach adopted likely to be acceptable to a reasonable person.

**Future proof** is closely related to issues of robustness, in that an assessment approach that gives results that are not strongly affected by reasonable changes in habits nor significantly affected by changes in the environment is more future proof. Consideration has to be given to the current characteristics of the locality and also to reasonably foreseeable changes on a timescale of a few years that may lead to habits changes that could increase assessed doses. It is likely that the approaches adopted where site-specific habit data are not available are cautious, and, therefore, strongly future proof, particularly when a screening approach is used.

Ease of application is of considerable importance to small users, who may have only limited resource and experience with undertaking radiological impact assessments.

**Compliance with Principles** [see Refs 8 and 9]

Compliance of the habits data methods with the principles published in 2002 [Ref 8] was considered as part of the evaluation process. The outcome of the evaluation for each method is in reference 1 and summarised in Table A1. This shows that the profiles methods comply best with the principles. The principles were updated in 2012. The revised principles are very similar [Ref 9]. As the principles are similar a detailed re-assessment of compliance between the methods and the revised principles has not been undertaken. The evaluation scores against the 2002 principles have been taken to be appropriate.

## **Appendix B: Summary of the revised dose assessment principles [Ref 9]**

The most relevant assessment principles for habits data in prospective dose assessments are - Principles 1, 2, 3, 4, 5, 7, 9, 10.

<b>Principle 1</b>	<b>Prospective dose assessment methods, data and results should be transparent and made publicly available.</b>
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<b>Principle 2</b>	<b>Workers, who are exposed to discharges of radioactive waste, but do not work directly with ionising radiation and are therefore not normally exposed to ionising radiation, should be treated as if they are members of the public for the purpose of determining discharge permits or authorisations.</b>
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<b>Principle 3</b>	<b>When determining discharge permits or authorisations, the dose to the representative person should be assessed.</b>
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<b>Principle 4</b>	<b>Doses to the most affected age group should be assessed for the purpose of determining discharge permits or authorisations. Assessment of doses to 1 year old, 10 year old and adults (and fetus when appropriate) is adequate age group coverage.</b>
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<b>Principle 5</b>	<b>The dose to the representative person which is assessed for comparison with the source constraint and, if appropriate, the site constraint, should include all reasonably foreseeable and relevant future exposure pathways.</b>
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<b>Principle 6</b>	<b>Significant additional doses to the representative person from historical discharges from the source being considered and doses from historical and future discharges and direct radiation from other relevant sources subject to control should be assessed and the total dose compared with the dose limit of 1 mSv/y.</b>
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<b>Principle 7</b>	<b>Where a cautious estimate of the dose to the representative person exceeds 0.02 mSv/y, the assessments should be refined and, where appropriate, more realistic assumptions made. However, sufficient caution should be retained in assessments to provide confidence that actual doses received by the representative person will be below the dose limit.</b>
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<b>Principle 8</b>	<b>The assessment of dose to the representative person should take account of accumulation of radionuclides in the environment from future discharges.</b>
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<b>Principle 9</b>	<b>The realistic habits adopted for the representative person should be those which have actually been observed at the site, within a period of about 5 years. Changes to habits which are reasonably likely to occur should be taken into account.</b>
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<b>Principle 10</b>	<b>Land use and infrastructure should have sufficient capacity to support the habits of the representative person. Any changes to land use and infrastructure should be reasonably likely to occur over a period of about 5 years and be sustainable year on year for them to be considered.</b>
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<b>Principle 11</b>	<b>The dose assessed for operational short term release at proposed notification levels or limits should be compared with the source constraint (maximum of 0.3 mSv/y) and the dose limit (1 mSv/y), taking into account remaining continuous discharges during the remainder of the year and contributions from other relevant sources under control.</b>
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**Principle 12** For permitting or authorisation purposes, collective doses to the populations of UK, Europe and the World, truncated at 500 y, should be estimated.

**Principle 13** Where the assessed mean dose to the representative person exceeds 0.02 mSv/y, the uncertainty and variability in the key assumptions used for the dose assessment should be reviewed.

#### **About NDAWG Guidance Notes**

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