DEVELOPMENT OF A TOTAL RETROSPECTIVE DOSE ASSESSMENT METHODOLOGY

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RECOMMENDATIONS

It is recommended that NDAWG set up a subgroup on total retrospective dose assessment methodologies led by the Environment Agencies to devise a methodology to be used by the Environment Agencies for fulfilling their responsibility to assess and report total doses. The subgroup would:

- Steer a further trial on detailed total retrospective dose assessments around all nuclear sites.
- Propose which method (eg Hunt and Shepherd method or 97.5th percentile method) should be used to define the critical group.
- Discuss and propose plans for regular reporting of total retrospective doses to members of the public.
- Provide advice on the implementation of the full total dose methodology to encompass both nuclear and non-nuclear sites (ie initial screening assessment and generic regional assessments).

INTRODUCTION

1. The Euratom Basic Safety Standards (BSS) Directive 1996 [Ref 1] (Article 14) requires member states to assess regularly the total of all contributions of exposure to ionising radiations from practices subject to the Directive (ie practices involving a risk from ionising radiation). Directions on the Environment Agency (EA) and Scottish Environment Protection Agency (SEPA) [Refs 2, 3] require these Agencies to ensure that the sum of doses do not exceed the dose limits specified in the BSS, in discharging their functions in relation to the disposal of radioactive waste under the Radioactive Substances Act 1993. The Radioactive Waste Policy Group of the Department for Environment, Food and Rural Affairs (DEFRA) has recommended that the Environment Agencies (ie EA, SEPA and Department of Environment, Northern Ireland) should take the lead on assessing and reporting on compliance with dose limits.

2. The EA and SEPA separately identified the need to develop a methodology for the retrospective assessment of doses from multiple sources disposing of radioactive waste, allowing for all exposure pathways associated with these sources and associated wastes. The EA contracted AEA Technology to undertake an R&D project to develop the methodology [Ref 4]. The R&D project was managed as a collaboration between the EA, the Food Standards Agency (FSA) and the Nuclear Installations Inspectorate (NII).

3. This NDAWG paper summarises the conclusion of the methodology development work and provides recommendations for implementation of the methodology.

BACKGROUND

4. A previous joint NRPB, MAFF, HMIP and HSE study was undertaken to assess total doses from all exposure pathways around nuclear sites [Ref 5]. This study was based largely on existing assessment methods with the additional selection of a hypothetical population group who could be exposed from a variety of pathways. The study did not methodically address the combined impact from a number of sources of discharges nor did it include discharges from non-nuclear sites.

5. In 2000 the FSA organised a Consultative Exercise on Dose Assessment. One of the outcomes was support for work on methodologies for the assessment of total dose [Ref 6].

SCOPE OF ASSESSMENT METHODOLOGY

6. The scope of the assessment methodology in the R&D project was established as follows:

- ***Dose Type*** - Given the requirement of the Direction on the EA to assess doses for comparison with the dose limit, it was agreed that the methodology development should focus on individual effective dose rather than collective dose.
- ***Sources of exposure*** - The total dose to be assessed is to be compared against the dose limit and is thus the dose arising from all practices covered by the BSS (excluding medical exposure). Clearly, direct radiation, in particular from nuclear sites should be included in the assessment of total dose. Additional sources of exposure have been highlighted, namely discharges exempted from RSA 93, routine and accidental discharges from sources outside the UK and fallout from weapons testing. It was considered that there was no merit in attempting to separate out the doses from these additional sources of exposure, where doses are derived from environmental monitoring data.
- ***Reference groups*** - The BSS defines a dose limit for "members of the public", but does not define whether the dose to an individual member of the public or the mean dose for a reference group is compared to this limit. The Direction to the EA [Ref 2] states that the dose to any member of the public should not exceed the dose limits for members of the public given in Article 13 of the BSS. The Direction to SEPA [Ref 3] limits doses to population groups. For the purpose of the R&D study it was agreed that the mean dose for reference population groups would be assessed and this could be taken to be the same as the mean dose for the critical group, in line with the draft statutory guidance to the EA [Ref 7].

OVERVIEW OF PROPOSED METHODOLOGY

7. A three stage assessment methodology was proposed:

- Preliminary Screening Assessment
- Generic Regional Assessment
- Detailed Site/Area Assessment

8. The purpose of the three stages was to screen out those sites and areas where doses are low so that effort can be focussed on areas where doses need to be assessed in more detail. The process would start with the preliminary screening assessment which makes use of generic modelling to predict the environmental concentrations results from the disposals (Appendix 1).

9. If the estimated dose from the screening approach were above an agreed dose criteria the assessment would be followed up with a generic regional assessment (Appendix 2), again using modelling to predict the environmental concentrations. Depending on the result, the generic assessment may then need to be followed up with a detailed site specific or area assessment (Appendix 3), making use of available monitoring data and modelling where monitoring data is not available.

10. The first two stages were tested on sites authorised to discharge radioactive waste in the Agency's Thames region (see Appendices 1 and 2). The detailed assessment stage was tested on the Sellafield area (see Appendix 3).

REVIEW OF PROPOSED METHODOLOGY

11. The proposed methodology for assessing total retrospective doses to members of the public involves an initial screening stage to identify the significant discharges, a generic regional assessment to highlight important areas (eg around a nuclear site, or river catchment) for more detailed study and a proposed method for undertaking detailed assessments.

12. The initial screening method is probably necessary to ensure that assessment effort is focused on the significant discharges. However, a screening level of 60 μSv/y was chosen in the R&D study which is not consistent with the screening level of 20 μSv/y chosen in the draft document 'Principles for the Assessment of Public Doses' [Ref 8].

13. The generic regional assessment method successfully highlights the important sites and areas within a region which would require more detailed assessment. However, the proposed method includes the simple but artificial location of exposed population groups in every grid square. This simplistic approach will probably undermine the presentation of results from this method. An adaptation of the method may be to select hypothetical exposed groups based on regional knowledge (eg located in vicinity of one site making atmospheric discharges and angler on local river receiving discharges upstream). The method as proposed does not allow for direct radiation which may be important around some nuclear sites.

14. The detailed site/area assessment is logical and comprehensive. However, the trial which was undertaken in this study did not have access to fully integrated habit data for the high seafood consumers and a further trial with improved data would be valuable. The acceptability of in-filling of monitoring data and assuming that less than values are positive results needs further investigation. A simplification to the method has been described and the validity of this revised method should also be investigated.

15. A further important area for debate is the protocol to be used for selecting the members of a critical group (eg Hunt and Shepherd method or 97.5th percentile method). Finally, the means by which total doses are assessed and reported needs to be discussed in a wider collaborative manner and plans made for such reporting.

CONCLUSIONS

16. It is proposed that a further trial of the detailed assessment method is undertaken based on 2001 monitoring and discharge data for all nuclear sites. This trial would need to involve EA, FSA and NII and could also include NRPB, CEFAS and SEPA if they are willing to participate. This further trial would investigate the validity of the proposed simplification to this method and the validity of in-filling data or modelling data, treating detection limit values as real values and further develop tools for the assessment process.

17. A sub group of NDAWG should be set up to steer this total dose work and to address future important issues such as the manner in which total retrospective doses are regularly reported (eg annually), debate the method to be used for selecting members of the critical group and advise on the implementation of full methodology including initial screening and generic regional assessments.

REFERENCES

1. Council Directive 96/29/Euratom of 13 May 1996 *Laying Down Basic Safety Standards for the Protection of the Health of Workers and the General Public Against the Dangers Arising from Ionizing Radiation*. Official Journal of the European Communities, L159, Volume 39, 29 June 1996.

2. The Radioactive Substances (Basic Safety Standards) (England and Wales) Direction 2000.

3. The Radioactive Substances (Basic Safety Standards) (Scotland) Direction 2000.

4. J J Hancox, S J Stansby and M C Thorne (2002). The Development of a Methodology to Assess Population Doses from Multiple Sources and Exposure Pathways of Radioactivity. Environment Agency R&D Project P3-070 (in publication).

5. Robinson C A, Mayall A, Attwood CA, Cabianca T, Hodd D H, Fayers C A, Jones K A and Simmonds J A (1994). *Critical Group Doses around Nuclear Sites in England and Wales*. NRPB-R271.

6. Food Standards Agency (2001). *Consultative Exercise on dose Assessments (CEDA) – Discussion of the methods of assessing the impact of radioactive discharges on the public. Held at University of Sussex, 3-4 October 2000*. Radiological Protection and Research Management Division, Food Standards Agency, London.

7. The Environment Agency and the Regulation of Radioactive Discharges into the Environment from Nuclear Licensed Sites. Incorporating: Part I Statutory Guidance to the Environment Agency Made Under Section 4 of the Environment Act 1995. Part II Explanatory Document Accompanying the Statutory Guidance.

8. Environment Agency, Scottish Environment Protection Agency, Northern Ireland Department of Environment, National Radiological Protection Board and Food Standards Agency. Authorisation of Discharges of Radioactive Waste to the Environment. Principles for the Assessment of Public Doses (to be published 2002).

9. Titley J G, Attwood CA and Simmonds J R (2000). Generalised Derived Constraints for Radioisotopes of Strontium, Ruthenium, Iodine, Caesium, Plutonium, Americium and Curium. *Doc NRPB*, **11(2)**, 1-41.

10. G Burholt and A Martin, *Radiological Assessment of Radioactive Waste Disposal from Non-Nuclear Premises in Anglian Region, Volume 1 – Methodology*, Report to the EA under Contract Ref. P0035/DOSE/CT, AMA/J95/R1, 1999.

11. Mayall A et al (1997). *PC-CREAM Installing and using the PC system for assessing the radiological impact of routine releases*. National Radiological Protection Board. EUR 17791 EN, NRPB-SR296.

12. Environment Agency (2001). Modelling of the Combined Impact of Radionuclide Discharges Reaching Rivers. R&D Technical Report P3-068 (in publication).

13. Simmonds J R, Lawson G and Mayall A (1995). *Methodology for assessing the radiological consequences of routine releases of radionuclides to the environment*. European Commission, Luxembourg, EUR 15760 EN, Radiation Protection 72.

14. FSA and SEPA. *Radioactivity in Food and the Environment, 1999*. RIFE-5.

15. G J Hunt and J G Shepherd (1980). The identification of critical groups. IN A Eisenberg (editor). Radiation Protection: A Systematic Approach to Safety. Volume 1, Proc 5th Int Congr IRPA, Jerusalem. Pergamon Press, Oxford & New York.

16. Environment Agency. *Radioactivity in the Environment*. Annual Report for 1999.

17. ICRP (1996). Age-dependent doses to members of the public from intake of radionuclides. Part 5. Compilation of ingestion and inhalation dose coefficients. ICRP Publication 72. *Ann ICRP* **26**, No 1.

APPENDIX 1 - PRELIMINARY SCREENING ASSESSMENT

The basis of this preliminary screening assessment is to assess the dose to a critical group from one particular site discharging radioactive waste, and to also include the contribution of dose to the critical groups for other sites in the region.

Methodology for the Calculation of Individual Site Doses

Discharges to atmosphere, river and sewer as appropriate from each site were considered.

For discharges to atmosphere, the dose pathways considered were plume inhalation, plume radiation, radiation from deposited radionuclides and exposure to radionuclides ingested in affected foods.

For discharges to sewer the dose pathways considered took account of exposure of sewage workers at the works during treatment of effluents and sludges containing radionuclides, exposure arising from application of sludges to land, including ingestion of food stuffs produced on the land and exposure arising as a result of radionuclides in treated effluents reaching controlled waters, including ingestion of radionuclides in drinking water, fish and direct radiation from radionuclides on the river bank.

For discharges direct to river, the pathways considered were ingestion of radionuclides in drinking water, fish and direct radiation from radionuclides on the river bank.

The assessment was based on modelling discharges and made use of data on dose per unit discharge to atmosphere, river and sewer. These data were collated from NRPB Generalised Derived Constraints [Ref 9] and other EA R&D [Ref 10], supplemented as necessary with additional data derived using the PC CREAM model [Ref 11]. The main assumptions associated with the modelling and the assessment are shown in Tables A1.1, A1.2 and A1.3.

1999 discharge data was collated for the Thames region as part of this study and other R&D [Ref 12]. These data combined with the dose per unit release data enabled doses from discharges to atmosphere (D_A), doses from discharges to controlled waters (D_W) and the dose from discharges to sewer (D_S) to be evaluated for the individual sites.

Methodology for Calculation of Total Screening Doses

The individual site doses (eg D_A) were then multiplied by a factor to take account of the contribution that each individual site can make to other critical groups in the locality. For example, in the case of discharge to controlled waters, there may be a number of critical groups for other discharges into the river further downstream. The dose from discharges to water was then multiplied by a factor which in this case was an estimate of the number of other critical groups which are downstream of the object critical group which might be affected by the discharge. A total screening dose was calculated for discharges to atmosphere (D_{AT}) controlled waters (D_{WT}) and sewer (D_{ST}).

The total assessed dose can then be compared to a defined screening level to see whether a more detailed assessment is required. For a site not to be considered for more detailed assessment then the total dose should be less than the screening level (D_{TL}) as follows:

$$D_{AT} + D_{WT} + D_{ST} \leq D_{TL}$$

A screening level D_{TL} of 60 μSv/y was chosen for the R&D study as this is approximately the lower bound of the estimated doses to critical group members from releases at licensed sites found in previous studies [Ref 5]. In future, a screening level D_{TL} of 10 or 20 μSv/y could be applied separately to each discharge route.

Result of Trial for Thames Region

The total doses arising from discharges from a total of 170 sites within the Agency's Thames Region were assessed, of which 4 were nuclear sites. 45 sites exceeded the screening dose criteria of 60 μSv/y adopted for the work. The total doses for 42 of these sites were dominated by the dose from the discharges to sewer or controlled waters. Of the 4 nuclear sites, the Harwell and Amersham nuclear sites were identified for further assessment, however, the doses for Aldermaston and Burghfield nuclear sites were below the screening dose criteria.

An assessment of doses from direct radiation is not included in the screening approach. Direct radiation is an important dose pathway for some nuclear sites and not including the pathway could lead to some sites being screened out. In the Thames test case, nuclear sites where direct radiation could give doses above the screening dose criteria also gave doses above the screening criteria as a result of their discharges.

Comment on Practical Application of Methodology

The doses calculated by this screening process are derived on a pessimistic basis and ranged well beyond 1 mSv/y due primarily to the selection of un-realistic surrogate radionuclides. Therefore the results of the preliminary screening assessment are not reportable since they are not realistic doses. Modification of the method with more appropriate site specific dose per unit discharge factors in particular in relation to discharges to sewers and controlled waters would enable more realistic doses to be presented. However, the refinement of the approach is probably only worthwhile if doses are to exceed the agreed screening level.

The screening dose criteria will need to be generally accepted. The value of 60 μSv/y adopted is not consistent with the draft Principles for the Assessment of Public Doses [Ref 8]. A screening level of 20 μSv/y may be more appropriate for example BASIS of 20. If 20 μSv/y were adopted in the test case, the number of sites to be considered for the next stage of the assessment would be about 80.

Table A1.1 Parameter Values for Dose per Unit Release to Atmosphere

Parameter	Unit	Value
Stack height	m	15
Distance to exposure location	m	300
Distance to location for source of food	m	500
Inhalation rate	m^3/y	7300
Cloud γ location factor	-	0.2
Deposited γ location factor	-	0.1
Consumption of local food		
Beef	kg/y	45
Milk	l/y	240
Milk Products	kg/y	60
Cow Liver	kg/y	10
Sheep Meat	kg/y	25
Sheep Liver	kg/y	10
Green Vegetables	kg/y	80
Root Vegetables	kg/y	130
Fruit	kg/y	75
Occupancy at exposure location	h/y	8760
Fraction time spent indoors	-	0.5

Table A1.2 Parameter Values for Dose per Unit Release to Controlled Water (Including Treated Effluent from STW)

Parameter	Unit	Value
Drinking water consumption	l/y	600
Freshwater fish consumption	kg/y	2
River bank occupancy	h/y	500

Table A1.3 Parameter Values for Dose per Unit Release to Sewer

Parameter	Unit	Value
Raw sewage flow through STW	m^3/day	10^5
STW Worker Doses		
Occupancy (inhalation pathway)	h/y	2000
Occupancy (other pathways)	h/y	1000
Worker breathing rate	m^3/h	1.2
Inadvertent ingestion rate	kg/h	$5\ 10^{-5}$
Resuspended sewage concentration	mg/m^3	0.1
Sewage Sludge Land Application Doses		
Sludge application rate	kg/m^2	1
Occupancy on treated land	h/y	1000
Green vegetables consumption rate	kg/y	80
Root vegetables consumption rate	kg/y	130
Fruit consumption rate	kg/y	75

APPENDIX 2 - GENERIC REGIONAL ASSESSMENT

For the generic regional assessment, a method was proposed in which would allow doses to be assessed from more than one disposer. The method assessed doses to population groups in every 1 km grid square.

For releases to atmosphere, doses were calculated for the 1 km grid square in which the site is located and doses to surrounding 1 km grid squares in Thames region were scaled in proportion to the relative ground level air concentrations due to atmospheric dispersion. The same dose pathways were considered as in the preliminary screening assessment and the same dose per unit release data were used.

For releases to rivers in the Thames region (including those from the sewage treatment works), the combined discharges for each reach of the river were calculated and with information on the river flow rate in each reach, the doses associated with the discharges to each reach were assessed. An algorithm based on that in Reference 13 was used to derive doses from the transport of radionuclides to downstream river reaches. It was assumed that population groups would travel up to 20 km to utilise the river. Therefore, the total dose for each river reach was assumed to apply up to 20 km perpendicular to each river reach (see Figure A2.1). The same dose pathways were assumed and the same dose per unit release values were used as in the preliminary screening assessment.

Dose arising from disposal of sewage sludge to land were assumed to occur as a result of sewage sludge applied to land over a distance of 10 km from each sewage works and sewage workers were assumed to live up to 30 km from a sewage treatment works (see Figure A2.2). The same dose pathways were assumed and the same dose per unit release values were used as in the preliminary screening assessment.

1999 discharge data was collated for the Thames region as part of this study and other R&D [Ref 12].

The total dose in each 1 km grid square was assessed and the critical group dose for the region identified.

Result of Trial for Thames Region

The 45 sites in Thames Region which exceed the preliminary screening level were assessed as part of this generic regional assessment. The maximum overall dose for Thames region and maximum doses for individual disposal routes/exposure pathways are shown in Table A2.1. The maximum overall dose was estimated as 78 μSv/y, predominantly due to atmospheric discharges from Amersham plc. It should be noted that this is still a generic assessment with cautious assumptions including the assumption of milk production near the site. Thus, for Amersham plc, the doses will have been a lot lower (a dose of 8 μSv/y was reported in Reference 14) as there is no milk production within about 2-3 km of the site.

However, the generic regional assessment as applied in this trial, did not allow for doses from direct radiation. The method identifies Amersham as the most important in terms of dose. The assessed dose from Amersham including direct radiation to the critical group may therefore be higher than that reported.

The maximum doses for discharges to sewer or river is estimated as 65 μSv/y. The source of the discharges giving the majority of this dose are from the North Middlesex Hospital which discharges to the Deephams Sewage Treatment Works (STW).

Comment on Practical Application of Methodology

Most assumptions in the assessment method are cautious and thus the results cannot be reported as a definitive regional assessment. As previously stated the assessment is cautious for atmospheric discharges from Amersham plc. The treated effluents from Deephams STW discharges to a small brook which realistically could not support freshwater fish. However the methodology only assumed consumption of fish from all rivers and brooks in the Thames region at a rate of 2 kg/y. Other R&D undertaken by NRPB and the Centre for Ecology and Hydrology [Ref 12] on doses from combined discharges to the River Thames has used consumption rate for freshwater fish of 2-20 kg/y.

The artificial location of exposed population groups in each 1 km grid square is also unrealistic but provides for a simpler assessment. An improvement to the method might be to select more realistic locations for exposed population groups.

As a result of the preliminary screening and generic regional assessment for the Thames region, it is likely that the Amersham area and discharges (direct or via sewer) to the Thames river and estuary would have been carried forward for more detailed assessment. In the case of discharges to the Thames estuary, then it is probable that only those sites exceeding a preliminary screening level would be carried forward for detailed assessment.

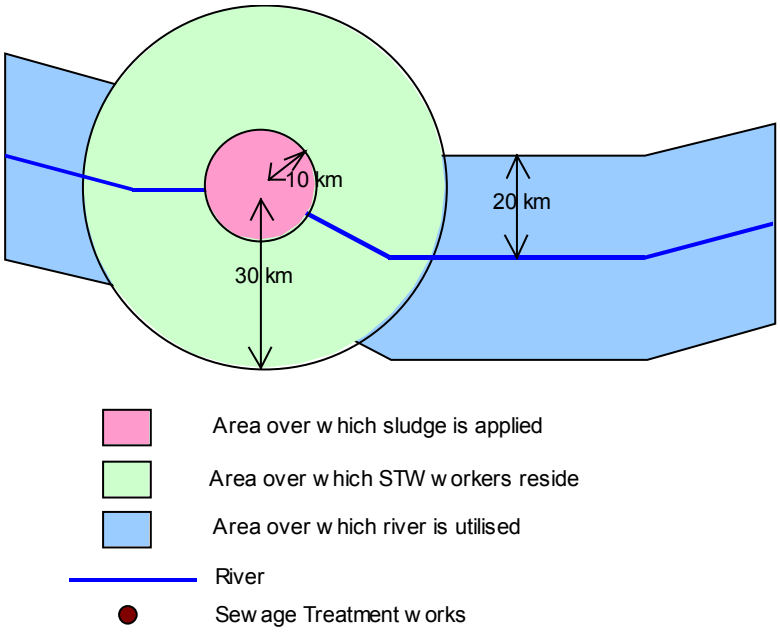

Figure A2.1 Spatial Extent of Doses from Rivers and STW in the Generic Regional Assessment

Table A2.1 Results of Generic Regional Assessment for Thames Region

Discharge Route / Exposure Pathway	Maximum Dose (μSv/y)	Major Source of Discharges
Maximum dose all disposal routes and exposure pathways	78	Amersham plc
Atmosphere	58	Amersham plc
River/Sewer	65	Discharges from Deephams STW which receives discharges from North Middlesex Hospital
Sludge application to land	17	Disposal from Maple Lodge which receives discharges from Amersham plc
STW Worker	2	Sandford STW receiving discharges from hospitals, universities and pharmaceutical companies in Oxford area

APPENDIX 3 - DETAILED SITE/AREA ASSESSMENT

The methodology for the detailed site or area assessment is intended to focus on those sites which have the highest doses in the regional assessment. It is also intended to be realistic, consider all significant discharges and exposure pathways in the vicinity of a site and is likely to be based to a large extent on monitoring data where such data is available.

The methodology allows for exposure to atmospheric discharges, discharges to sewer and discharges to controlled waters. The methodology also allows for exposure to direct radiation.

Environmental Concentrations and Dose Rates

For atmospheric discharges, where monitoring results are available they would be used, in particular for foodstuffs around the site. Where monitoring results are not available data would be modelled based on discharges (eg ambient air concentrations).

For discharges to sewers, monitoring results are mostly not available. Therefore, environmental concentrations would need to be based on modelling. In some cases, the river environment that receives discharges of treated effluent from sewage works is monitored. Where monitoring data are available, the results would be used.

For discharges to rivers, some monitoring results are available. Where monitoring data are available, the monitoring results would be used.

For discharges to the marine environment, monitoring results are available.

Measurements of direct radiation dose rates around nuclear sites would be provided via the NII.

Habit Data Requirements

The methodology requires a dataset of the habits of a large number of individuals living around the site which can lead to their exposure to radionuclides or radiation (eg food consumption rates, occupancy rates). These habits need to be linked to 'domains' or areas around a site (eg live within 1 km on land, seafood from within 15 km of site).

Dose Calculation Methodology

The dose per unit occupancy or per unit consumption of food within these domains was evaluated based on radionuclide activity concentrations in food, air etc and the dose factors for consumption of radionuclides in food or inhalation of radionuclides in air etc. Doses are then calculated for each individual within the habit data set. Individual doses for each radionuclide, environmental material and domain were calculated according to the following formula:

$$H_{ijkl} = M_{ijl} C_{ijkl} S_{jk}$$

Where:

H_{ijkl} is the committed effective dose to individual *i* due to exposure to radionuclide *k* in environmental material j in domain *l* during the year in question;

M_{ijl} is a measure of the interaction of individual *i* with environmental material *j* in domain *l* over the year in question;

C_{ijkl} is the average concentration of radionuclide *k* in the sample of environmental material *j* in domain *l* that individual *i* encounters over the year in question;
S_{jk} is a mapping function that relates unit interaction with environmental material *j* exhibiting unit concentration of radionuclide *k* to committed effective dose. This does not depend on the individual, but can depend on the population group under consideration (ie infant, child, adult).

The total dose for each individual may be expressed as follows:

$$H_i = \sum_{jkl} M_{ijl} C_{ijkl} S_{jk}$$

To make this more robust, for ingestion of a particular type of food, *M* would be the annual consumption (kg/y), *C* would be the average concentration in the environmental material consumed (Bq/kg) and *S* would be the intake to committed effective dose factor (Sv/Bq). Environmental materials are food, water, soil, air. Direct radiation is simply location near the site.

For external exposure, *M* would be the annual occupancy of a particular area (h/y), *C* would be the average concentration in the material externally irradiating the individual (Bq/kg) and *S* would be the dose rate (Sv/h) due to exposure to the material externally irradiating the individual if it were contaminated at unit concentration (1 Bq/kg). Alternatively, measurements of dose-rate may have been made in which case the combination of *CS* is the dose rate (Sv/h), excluding background.

The mean critical group dose has been evaluated using the Hunt and Shepherd method [Ref 15]. This is based on the ICRP homogeneity principle, that where doses approach a limit or constraint the variation in the doses in a critical group should be no greater than a factor of three. Therefore the mean dose for those individuals which have a dose greater than one third of the maximum dose has been taken to be the critical group dose. Within the project steering group, the EA and NII were happy to accept this approach. However, FSA wished to reserve their judgement.

Application of Methodology to Trial in Sellafield Area

The method was applied to the Sellafield area. The environmental materials which were considered in the assessment are shown in Table A3.1 and the domains selected are shown in Table A3.2. Monitoring data from EA's Radioactivity in the Environment Report for 1999 [Ref 16] and FSA's and SEPA's RIFE-5 Report [Ref 14] were used to provide concentrations of radionuclides in food and dose rates over sediment. Where there were no monitoring data for radionuclides in environmental materials in particular domains, data was in-filled using suitable surrogates. For example, if there were no ^{239}Pu activity concentration data for lobster in the near domain, then ^{239}Pu activity concentrations for lobster in the near domain might be assumed.

Discharges as reported in Reference 16 were used with PC CREAM modelling to establish concentrations of radionuclides in air and deposited on soil. Direct radiation dose rate data was supplied by the NII. FSA supplied the habit dataset. Dose coefficients were taken from ICRP-72 [Ref 17]. The monitoring data includes the influence of the Rhodia Consumers' discharges to the Irish Sea. Discharges from other sites in the vicinity of Sellafield (including Windscale) are negligible compared to those from BNFL Sellafield.

Fully integrated habit data for the occupancy rates (eg over sediments) and the terrestrial food consumption rates relating to high seafood consumers was not available to this project. Probabilistic sampling techniques (including use of the Palisade @risk™ tool) were used to derive a fully integrated dataset.

Result of Trial in Sellafield Area

The trial of the detailed site/area assessment was carried out in the Sellafield area. Two mean critical group doses were calculated, one including the residues PAST of discharges from Sellafield and from Rhodia Consumer Specialities (which discharged ^{210}Pb and ^{210}Po) and one allowing for past discharges from Sellafield only. Allowing for Rhodia's discharges, the dose was evaluated as about 0.7 mSv/y for the Sellafield area. Excluding the concentrations of ^{210}Pb and ^{210}Po from Rhodia's discharges reduced the mean critical group dose to about 0.2 mSv/y. These doses are consistent with those reported in RIFE-5 [Ref 14].

The dose assessment methodology included a protocol for the in-filling of monitoring data where there was a lack of activity concentration data for different radionuclides and environmental materials (including food). Direct radiation was included in the assessment. Monitoring results below the detection limit were considered to be valid results and were included. Since there was no ambient air monitoring data and limited soil monitoring data, the doses from inhalation, cloudshine and groundshine pathways were derived by modelling dispersion.

The mean critical group dose method employed was based on the Hunt and Sheppard [Ref 15] approach, in which the mean dose for those individuals who have a dose greater than one third of the maximum dose is calculated. However, the approach will predict doses that are lower than the maximum dose to a few individuals who are most exposed. The frequency distribution of the doses including and excluding ^{210}Pb and ^{210}Po are shown in Figure A3.1. The maximum dose is slightly higher than 1 mSv/y. However, the majority of the dose is due to consumption of seafood incorporating ^{210}Pb and ^{210}Po for which the natural background concentrations are not known with any certainty. Also, there has been in-filling of monitoring data. If data in-filling is not included, the maximum dose would be reduced to below 1 mSv/y (see Figure A3.2).

Comment on Practical Application of Methodology

This methodology requires a considerable amount of data and fairly extensive processing of that data. However, it provides a logical and comprehensive means for ensuring the total dose from all sources and pathways in an area are evaluated.

However simplification of the methodology might be possible. This could involve the pre-processing of a set of integrated habit data as follows:

- Select one food or occupancy type for which there is habit data (eg lobster consumption).
- Select the group of 'critical' individuals for this food or occupancy type using the Hunt method (ie group with consumption rate greater than one third of maximum).
- Derive mean consumption and occupancy rates for all the individuals in this group for all food and occupancy types or use values from integrated habit surveys where appropriate.
- Repeat for other food or occupancy types in turn.
- Result will be up to 60 sets of habit data which can be treated as being habit data for surrogate individuals in the methodology.

The advantages of this revised approach are that there will be some reduction in data processing and the habit data used can be published as data for candidate critical groups.

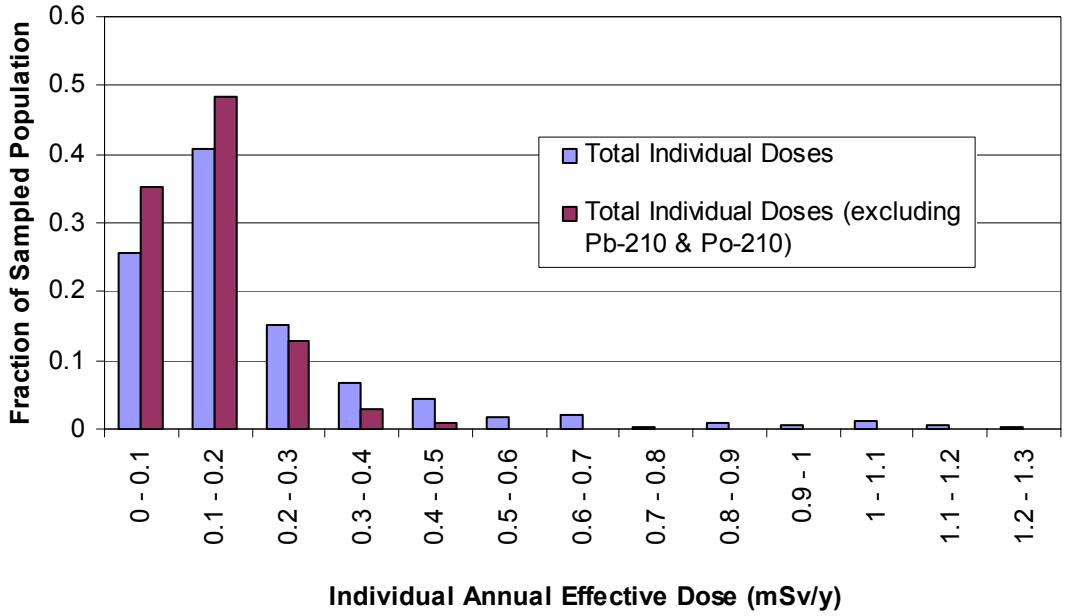

Figure A3.1 Distribution of Individual Doses for the Sellafield Area Assessment

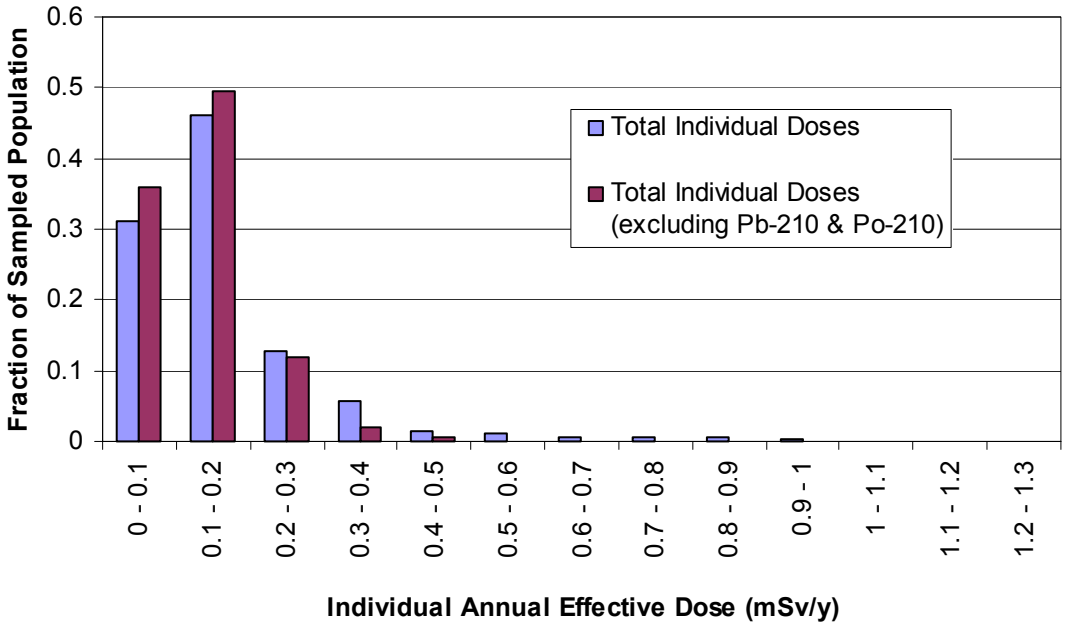

Figure A3.2 Distribution of Individual Doses for the Sellafield Area Assessment (No In-Filling of Monitoring Data)

Table A3.1 Environmental Materials and Exposure Modes Selected for Sellafield Area Assessment

Environmental Material	Exposure Modes	Corresponding habit data
Installation (Direct shine)	External radiation	Occupancy (h/y)
Air	Inhalation External radiation (cloudshine)	Occupancy (h/y)
Soil	External radiation (deposited activity)	Occupancy (h/y)
Sediment	External radiation	Occupancy (h/y)
Seafood Cockles, cod, crab, crustacea, fish, laverbread, limpets, lobsters, molluscs, mussels, nephrops, plaice, prawns, scallops, seaweed, shrimps, skate, squid, tinned laverbr'd, whelks, winkles	Ingestion	Consumption rates (kg/y)
Terrestrial food Apples, barley, beans, beef meat, beef offal, cabbage, carrots, cereals other, chicken, duck, eggs, fruit other, fungi other, grass, hares, honey, lettuce, meat other, milk, mushrooms, offal other, green veg other, root veg other, veg other, pears, pheasants, pig meat, pigeons, potatoes, poultry other, rabbits, sheep meat, sheep offal, swede, wild fungi	Ingestion	Consumption rates (kg/y)

Table A3.2 Domains Selected for Sellafield Area Assessment

Pathway	Near-field range	Far-field range
Marine food consumption	<15km	15km to 100km
Marine/foreshore occupancy[a]	<15km	-
Terrestrial food consumption	<1km	1km to 5km
Terrestrial occupancy (inhalation, groundshine, direct shine and cloudshine pathways)	<1km	1km to 5km

[a] The marine/foreshore environment may be further sub-divided by type. For example, in the trial application of the method presented in, two domains were used, namely mud/sand and salt marsh based on the availability of monitoring data.