Radiological impact assessment for the proposed Sizewell C nuclear power station

March 2023

Version 2

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Executive summary

NNB Generation Company Limited (SZC) (NNB GenCo (SZC)) are proposing to build and operate a new nuclear power station at Sizewell C, Suffolk. The proposed power station will have two pressurised water reactors based upon EDF and AREVA's UK EPR^{TM} design. In May 2020, NNB GenCo (SZC) applied for an environmental permit for the radioactive substances activities required for operation of the power station. NNB GenCo (SZC)'s permit application included an assessment of the radiological impacts of radioactive waste discharges on the public and the environment. This report presents our own independent assessment of the radiation doses, undertaken to provide a separate and independent point of comparison with NNB GenCo (SZC)'s assessment.

This report describes the work carried out on behalf of the Environment Agency to assess doses to members of the public and wildlife arising as a consequence of discharges of radioactive waste from the proposed Sizewell C nuclear power station. The assessments conducted follow national guidance provided by Public Health England (PHE) and the National Dose Assessment Working Group, in particular the "Principles for the Assessment of Prospective Public Doses". It also has regard to international advice published by ICRP and IAEA. The dose assessments undertaken use well established models, including PC-CREAM 08 (1.5.1.92/2.0.0), ERICA 1.3 and ADMS 4.2, and datasets such as those published in the IAEA technical report series.

Doses to individual members of the public were calculated for exposure resulting from the proposed Sizewell C radioactive discharges, direct exposure to radiation from Sizewell C and exposure resulting from historical and ongoing discharges from Sizewell A and B. The doses presented are the effective doses which would be received in the 60th year of operation and take into account the build-up of radionuclides in the environment. Our calculations indicate that individuals receiving the highest dose would be members of the adult sea fish consumers group, as defined in the CEFAS habit survey for the site. The total dose to this group from Sizewell C discharges and direct radiation was calculated to be 4.7 µSv y-1, this increases to 28 µSv y-1 with the inclusion of exposure to Sizewell A and B discharges and contributions from historic discharges.

Collective doses to UK, European and World populations were calculated for discharges from Sizewell C only. The collective dose was based on a single year of discharge but was integrated over time to account for the ongoing exposure of the population. In this study, collective doses were integrated over 500 years. Collective doses to the UK, EU and World populations from atmospheric discharges were calculated to be 0.4, 3.6 and 27.1 person Sv per year of discharge respectively. Collective doses to the UK, EU and World populations from marine discharges were calculated to be 0.04, 0.21 and 2.3 person Sv per year of discharge respectively.

Finally, absorbed dose rates to wildlife from routine discharges from Sizewell C were calculated. Wildlife inhabiting terrestrial, freshwater and marine habitats were considered. The highest dose rate, 0.23 µGy h-1, was calculated for insect larvae inhabiting a freshwater habitat in the Sizewell Marshes region. The dose rate to wildlife receiving the highest dose from all permitted radioactive discharges in the Sizewell region, was assessed to be 0.81 µGy h-1, this was calculated by combining the highest dose rate from routine SZC discharges with data from our RSR habitats assessment report 2017.

Contents

Note for readers

This version of the report differs from Version 1 in that it contains 2 small text amendments in Section 6 and in Table 11 where we have clarified that the total dose includes consideration of doses from future exposures of direct radiation from Sizewell A and Sizewell B. This is further discussed in Appendix 1 of our final decision document for the NNB GenCo (SZC) radioactive substances activity permit application.

1. Introduction

This report describes an independent radiological impact assessment of radioactive discharges from the proposed Sizewell C (SZC) nuclear power plant in Suffolk. The assessment has been carried out on behalf of the Environment Agency to support our determination of the radioactive substances activity permit application submitted by NNB Generation Company Limited (NNB GenCo) SZC.

The tiered approach to radiological impact assessment described in Environment Agency guidance (Environment Agency, 2006 a) has been used. The first two stages of dose assessment were undertaken using the Initial Radiological Assessment Tool (IRAT) (Environment Agency, 2006 a). This provides a simple and conservative indication of the potential doses to members of the public and can be used to decide if a detailed assessment is necessary. A detailed assessment is likely to be required if the estimated dose exceeds 20 μSv y-1. Stage 1 of the Initial Radiological Assessment (IRA) method, using the source term provided by the applicant, calculated doses of 110 μSv y-1 from atmospheric discharges and 370 μSv y-1 from liquid discharges. Stage 2 of the IRA calculated doses of 19 μSv y-1 for atmospheric discharges and 32 μSv y-1 from liquid discharges which indicated the need for a more detailed assessment.

The assessment described in this report considers the impact of the proposed discharges to atmosphere and liquid discharges at permitted limits from SZC on the representative person (RP). The RP represents those members of the public who are likely to receive the highest doses from the operation of SZC. Exposures to direct radiation and short-term planned discharges from SZC are also considered. In addition, prospective doses received by the RP as a result of current permitted discharges from Sizewell A (SZA) and Sizewell B (SZB) in combination with those from SZC are calculated. The radiological impact of historical discharges from SZA and SZB are also included in the assessment. Figure 1 summarises the steps in the dose calculation for the RP.

An environmental radiological impact assessment of discharges from SZC has also been carried out for local wildlife.

For each assessment, the approach adopted is consistent with that described in the dose assessment principles document (Environment Agency et al, 2012). The models used are well established and readily available and input data have been derived from recognised sources.

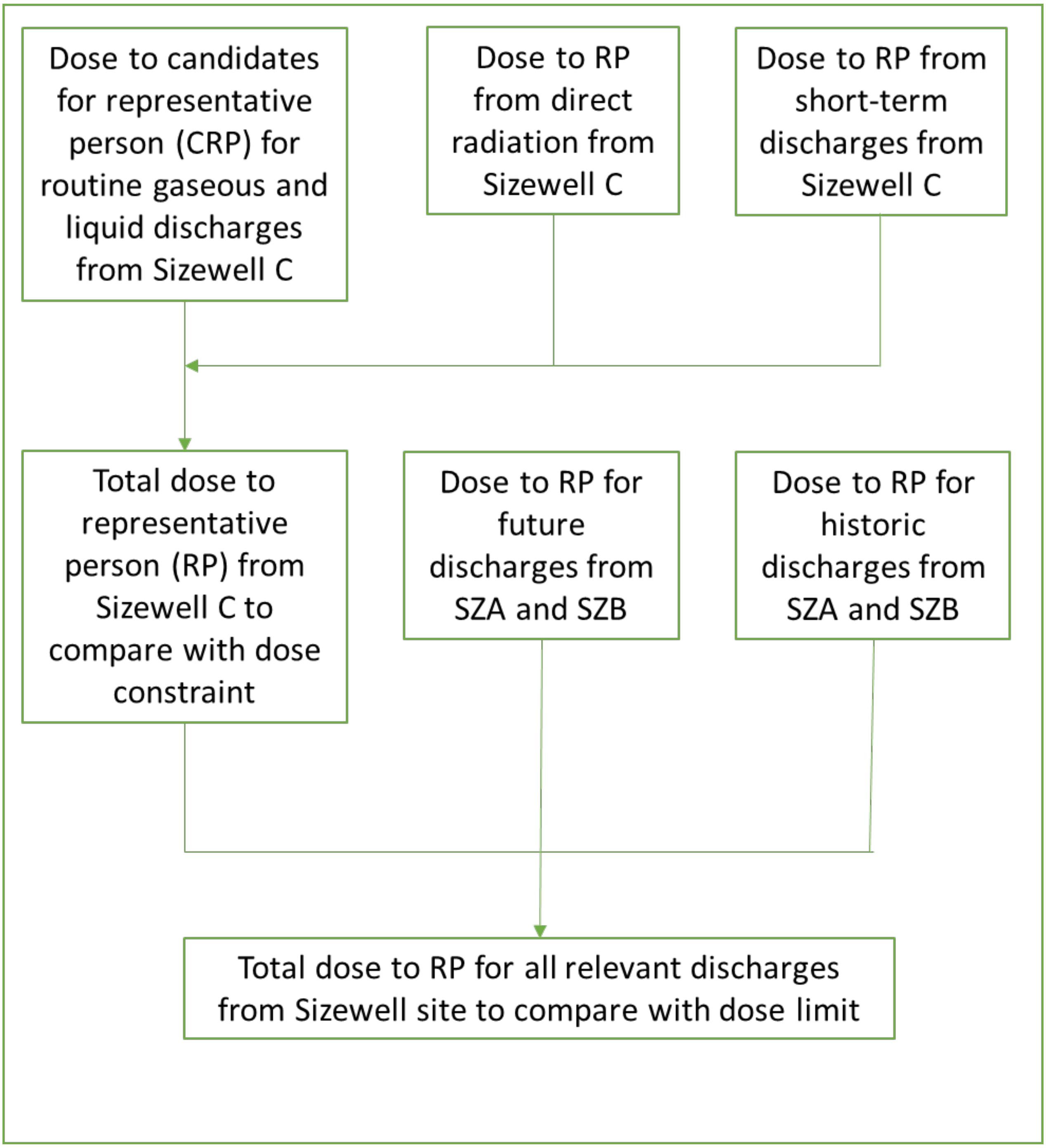

Figure 1 Schematic of steps in dose calculation for representative person

2. Description of the site

2.1. Site operations

The Sizewell site is situated near the village of Leiston on the Suffolk coastline. There are currently two nuclear power stations at the site: Sizewell A consists of two Magnox reactors that are being decommissioned, and Sizewell B is a single pressurised water reactor (PWR) that is currently in operation. NNB GenCo (SZC) intend to construct a new power station at the north end of the site (Sizewell C) which will be similar in design to the station being built at Hinkley Point C and will consist of two PWRs. The location of the proposed site is shown in Figure 2.

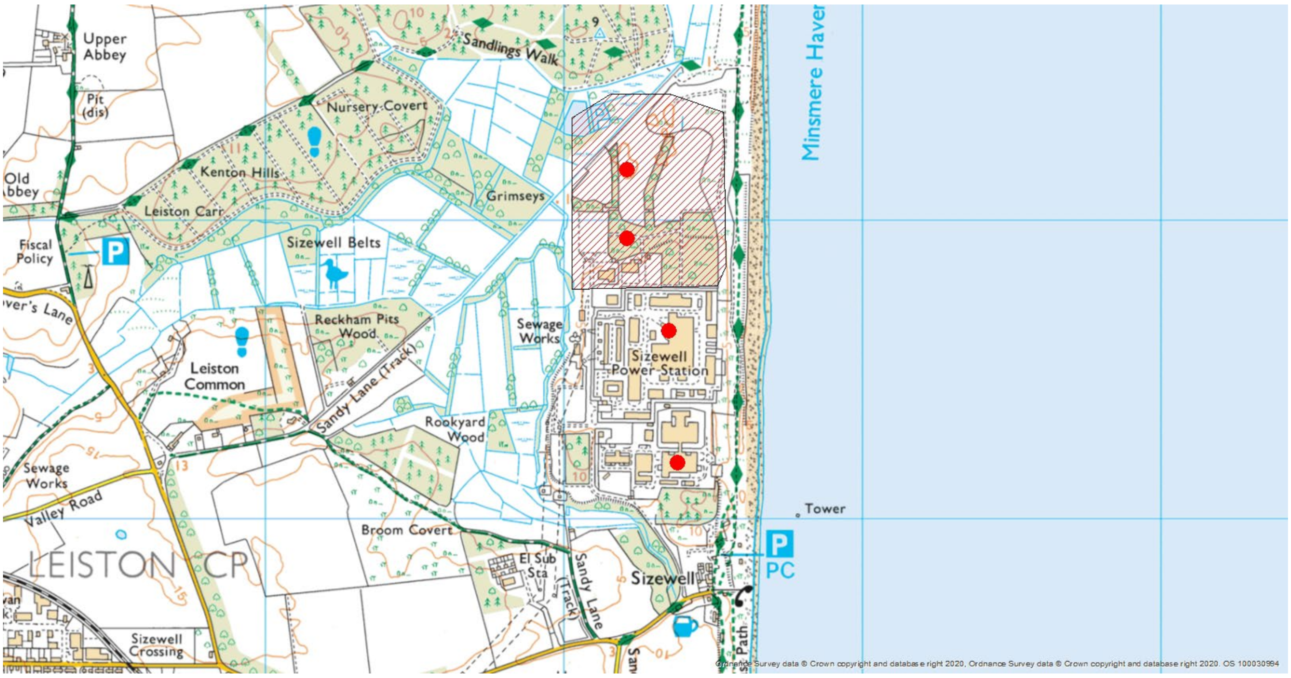

Figure 2 Sizewell nuclear site including proposed Sizewell C development (shaded red) and locations of discharge stacks used in the assessment (red circles).

2.2. Identifying locations for assessment of dose to Candidates for Representative Person

The aim of the dose assessment for humans is to ensure that members of the public exposed to ionising radiation, as a consequence of discharges from the Sizewell nuclear site, are adequately protected and do not receive doses that exceed the relevant dose criteria. Members of the public likely to receive the highest doses can be identified by their habits, for example they may consume higher quantities of local foods or spend more time outdoors near to the Sizewell nuclear site. Surveys are conducted near UK nuclear sites to gather habits data that can be used in radiological assessments. The habits data can be used to form habits profiles which represent groups of individuals likely to be most exposed to the discharges (NDAWG, 2005) (NDAWG, 2009). Each habits profile is considered a candidate for the representative person (CRP). Dose assessments are performed for each CRP and the one receiving the highest dose is identified as the representative person (RP) for the source being considered. It is the dose to the RP that is then compared to the dose limits.

In 2015 CEFAS conducted a habits survey around the Sizewell nuclear site (Garrod et al, 2016). The survey identified the key areas most likely to be affected by discharges from the Sizewell site, namely the aquatic survey area, the terrestrial survey area and the direct radiation survey area.

Within the aquatic survey area activities included angling, dog walking, attending to boats, fishing, playing, spending time on the beach, collecting marine plants, water sports and living on a boat. The consumption of marine foods included fish, crustaceans, molluscs, marine plants and wildfowl.

Within the terrestrial survey area several farms, market gardens and allotments were identified which between them produced beef cattle, lambs, pigs, cereals, root crops, green vegetables, soft fruit and eggs. Grass and maize were also grown on some farms for use as animal feed. Other foods identified in the survey included honey and wild animals, birds, plants and fungi.

Occupancy rates to determine direct exposure to radionuclides released from Sizewell and for direct shine from on-site sources were collected for predefined zones within the direct radiation survey area around the site. Residents, visitors, and people working and undertaking recreational activities in the area were considered, including workers within the nuclear licensed site area who were not site employees or contractors.

Specific locations for food production and occupancy were not identified in the CEFAS habit survey (Garrod et al, 2016) and therefore appropriate assumptions had to be made in order to undertake an assessment. The rationale behind the assumptions we made is discussed below and the locations selected are summarised in Appendix 1, Table A1.1. Figures A1.1 and A1.2, of Appendix 1, show the position of each location in relation to the Sizewell site.

In addition to using local habits profiles as described above we also undertook an assessment using UK generic habits data. This was done to account for some exposure pathways which are not currently present in the terrestrial survey area but which may occur during the lifetime of SZC.

2.2.1. Aquatic survey area

Liquid discharges from the Sizewell site will be made via two outfall pipes approximately 3.4 km offshore (NNB GenCo (SZC), 2020b). It was assumed that these would fall within the local marine compartment of the PC-CREAM 08 (Smith and Simmonds, 2009) marine dispersion model DORIS. DORIS was used to estimate activity concentrations in fish, crustaceans, molluscs, water and sediments in the local compartment. All marine food was assumed to be sourced from the local compartment (i.e. there is no contribution from the more distant regional compartment). Table A1.1, Appendix 1, lists the exposure pathways that are based on activity concentrations in the local marine compartment.

The CEFAS habit survey (Garrod et al, 2016) identified consumption of marine plants, mostly sea beet and samphire, harvested from salt marshes and river mouths. PC-CREAM 08 does not consider the consumption of these specific plants but does consider seaweed which was used as a surrogate.

2.2.2. Terrestrial survey area

Discharges to atmosphere from SZC will primarily be through two 70 m high emission stacks (NNB GenCo (SZC), 2020b). The power station complex lies on the coastline which runs approximately north-south (see Appendix 1, Figure A1.1). In the CEFAS survey habits were surveyed within a five kilometre radius from OS grid reference TM473634 (a point centred on the existing power station complex), this region is referred to as the "terrestrial survey area". Within the terrestrial survey area it is assumed that each foodstuff is produced at the same single location for supply to all consumers.

A wind rose generated from 5 years of recent site-specific meteorological data shows that the wind direction is towards the sea for about half the time (Figure 3). The most frequent wind directions inland are towards the north and the south-west. We used the wind rose to inform our decision about which locations to use for the various exposure pathways in the dose assessment.

Location for cultivated fruit and vegetables

The CEFAS habits survey found that a variety of fruit and vegetables were cultivated in market gardens, allotments and domestic gardens. The land to the north of the Sizewell site is largely marshland and unlikely to be suitable for cultivating vegetables, but Leiston (about a kilometre south-west of the power station complex) has two allotment sites. In this assessment, we assumed all fruit and vegetables were produced at one of these local allotment sites.

Location for eggs & poultry

Chickens kept for eggs were found in gardens and allotments in residential areas throughout the survey area, and in one market garden. The local allotment site used for cultivating vegetables was also chosen as the location for chickens kept for eggs.

Garrod et al (2016) did not identify any chickens kept for meat in the survey area, although it gives values for consumption of poultry. For this assessment, we assumed that chickens kept for meat are also located at the local allotment site.

Location for honey

Garrod et al (2016) identified two beekeepers in the survey. In this assessment, the local allotment site was chosen as a possible location for honey production.

Location for beef and lamb

Beef cattle and lambs are produced in the terrestrial survey area by a handful of farms. Garrod et al (2016) noted that beef cattle were grazed on the marshland near Minsmere, directly north of the power station complex. Sheep require similar grazing conditions to cattle. The location chosen for production of both beef and lamb was the salt marshes just south of Minsmere.

Location for pork

Garrod et al (2016) found that two farms raised pigs in the terrestrial survey area. Although these farms are not in the marshland region of Minsmere we assumed that pigs are reared at the same location as for beef cattle and lambs. This avoids unnecessary complication of the assessment and should not greatly affect the outcome because pigs are generally fed a clean, grain based, processed food. For this assessment pigs were assumed to be fed grain from the location where they are reared.

Location for milk and dairy products

Garrod et al (2016) found that dairy cattle were no longer kept in the terrestrial survey area and did not include the consumption of milk/dairy in any of the profiles. This is borne out of data from the Food Standards Agency (FSA), with which milk producers must register (FSA, 2020). Data retrieved for Suffolk show that the nearest registered establishment is about 15 km away from the Sizewell nuclear site to the north-west. Consumption of milk and dairy foods are therefore not included in the habits profiles used in our main assessment. We did undertake a separate more cautious assessment using generic habits to understand what the impact could be should dairy farming resume in the future, this is described in section 9.

Location for wild foods

Garrod et al (2016) found that fruit, nuts and mushrooms were collected in the survey area but specific locations were not identified. To the south-west of the power station complex and just over 1 km away is an area of common land. Part of the common is designated as Open Access land, a point was chosen where a public footpath crosses the Open Access land as a potential site for gathering wild foods.

Shooting of game (partridge, pheasant, pigeon, rabbit, venison) was found to take place on farms throughout the area, but as with other wild foods no specific locations were identified. To simplify calculations, game has been located at the same place as other wild foods.

2.2.3. Direct radiation and plume survey area

To assess doses arising from the inhalation of and external exposure to radionuclides in the atmospheric plume and from direct radiation (shine) we used the direct radiation and plume survey area identified in Garrod et al (2016). The survey area extended to 1km from the site and was divided into three distance bands from the existing licensed site boundary (or the perimeter fence in the case of beach occupancy). These distances are 0 km to 0.25 km (PLUME IN), >0.25 km to 0.5 km (PLUME MID), and >0.5 km to 1 km (PLUME OUT). Table A1.1, of Appendix 1, lists which exposure pathways we considered in the assessment during occupancy in these areas. The location occupied in each of these bands is assumed to be the same for all habits profiles that include occupancy in the relevant band.

Locations for occupancy in the plume

In the case of the inner band, rather than selecting a location within 0.25 km of the existing boundary, a site was selected to the north-east of the SZC stacks (i.e. in the direction of the prevailing winds) and within 0.25 km of the proposed SZC boundary.

Garrod et al (2016) noted that there were few habitations in the middle and outer distance bands. We selected the location of some nearby housing to represent the middle and outer distance bands for plume occupancy.

2.2.4. Candidates for representative person

In summary, the habits of the candidates for the representative person (CRP) were based on habit profiles derived from the habits survey data (Garrod et al, 2016). Where it was necessary to make a judgement about location, e.g. in relation to occupancy or food production, the assumptions described above were used. In this way, the CRPs were defined in terms of their habits and locations. The locations were used for the calculation of the environmental activity concentrations that were used in the dose assessment.

2.2.5. Location for generic assessments

As a cautious approach, to account for some practices not currently undertaken in the terrestrial survey area but which may occur during the lifetime of SZC, assessments were conducted for two additional receptor points. These are located 250 m and 500 m to the north of the north stack at SZC. It was assumed that all inhalation and external exposures occur at 250 m and all food production takes place at 500 m. Food production included milk and milk products. Habit data were based on the default values provided in PC-CREAM 08 and the top-two approach was used to identify the two food groups consumed at higher than average rates. The resulting doses were compared to those calculated for the representative person.

Similarly, a generic assessment of dose to individuals eating seafood and spending time near the coast was carried out using default assumptions in PC-CREAM 08.

2.3. Identifying wildlife habitats and species

The Sizewell nuclear site is surrounded by a diverse range of wildlife habitats and species. Many of these habitats are designated as protected sites under local, national and international law. Protected status is achieved locally e.g. through the County Wildlife Site (CWS) designation, nationally through Sites of Special Scientific Interest (SSSI) and internationally through RAMSAR and NATURA 2000 which includes Special Areas for Conservation (SAC) and Special Protection Areas (SPA). Many of these designations overlap such that the habitats fall under more than one designation (Suffolk Biodiversity Information Service, 2018). The SSSIs within 10 km of the Sizewell site were identified using the Natural England mapping tool (Natural England, 2020), see Appendix 2. We also considered the replacement SSSI wetland habitat at Aldhurst Farm.

Radiation exposure of wildlife in the vicinity of the Sizewell nuclear site will depend on many factors including local dispersion conditions, the type of habitat occupied, radionuclide uptake rates and behavioural patterns such as time spent at different locations. However, the significant diversity of habitats and wildlife species means that it is not possible to calculate dose rates to all species. Radiological impact assessment for wildlife is a developing field which is currently limited by the amount of data that are available to determine exposures to flora and fauna. Thus far, datasets have been compiled for some key organisms which were chosen to be representative of the large diversity of wildlife species and, consequently, radiological impact assessments generally focus on these key organisms. Such datasets are available from ICRP for Reference Animals and Plants (RAPs) (ICRP, 2008) and from the ERICA tool (Brown et al, 2016) for a set of reference organisms (ROs). Current guidance, (ICRP, 2008) and (IAEA, 2018), recommends that the impact of ionising radiation on wildlife and their habitats can be assessed by calculating dose rates to the RAPs or ROs. This assessment uses the ROs from the ERICA tool. If the dose rate to the most exposed RO is below the relevant criterion, and it can be demonstrated that the ROs are an adequate representation of the wildlife requiring protection, then it is reasonable to assume that the integrity of the habitat and wildlife that occupy it will be unaffected. An important step in this approach is to demonstrate a clear link between the wildlife to be protected and the ROs for which the dose assessment is carried out. Where this is not possible additional organisms must be included in the assessment.

The steps followed to identify the habitats and wildlife for consideration in this assessment are presented below.

- Identify protected areas within 10 km of Sizewell nuclear site, considering RAMSAR sites, NATURA 2000 sites (Habitats and Birds Directives) and SSSIs (Natural England, 2020). Also consider selected CWS designated sites (Suffolk Biodiversity Information Service, 2018).
- For each site give an overview of the habitat and resident wildlife. Include appropriate UK/EU protected species even if they are not listed in the wildlife surveys.
- Determine the closest sites where assessments to terrestrial, freshwater and marine organisms are required. It is possible that the closest site for one set of organisms is the same as that for another set e.g. terrestrial and freshwater organisms occupy the same site. For UK/EU protected species consider exposures at the location of highest concentrations even if there is currently no evidence that they reside there.
- Map types of organism to the ROs in ERICA (Brown et al, 2016) and determine if any additional organisms need to be modelled in ERICA. Demonstrate and justify the link between the wildlife to be protected and the ROs.

Following a review of all possible sites, it was concluded that the range of habitats and wildlife are well represented by three local sites: the southern end of Minsmere-Walberswick Heaths and Marshes SSSI, Sizewell Marshes SSSI and Outer Thames Estuary SPA. The first two of these sites include both terrestrial and freshwater ecosystems while the Outer Thames Estuary is a marine ecosystem. It was also decided that, with the inclusion of the badger and the bat groups, the default ROs in the ERICA tool would be an adequate representation of the wildlife inhabiting these sites. Further information regarding these decisions is presented in Appendix 2.

3. Doses from authorised discharges

3.1. Atmospheric discharges

This section describes the modelling of routine discharges to atmosphere that are expected to occur as part of the normal operation of Sizewell C (SZC) as well as those which already occur through the operations of Sizewell B (SZB), and the decommissioning of Sizewell A (SZA). Discharges at the proposed permit limits from SZC, and current permit limits for SZA and SZB were considered. In addition, because of the relatively high permit level for discharges from SZA compared to the current actual discharges, recent discharge data have also been considered for this station. The aim of the modelling exercise is to calculate the environmental activity concentrations that arise following dispersion and accumulation of radionuclides discharged to atmosphere. In this way, the spatial and temporal distribution of radionuclides around the site can be determined in order to calculate doses to individuals living nearby.

3.1.1. Source term

Discharges to atmosphere from the Sizewell sites are presented in Tables 1 to 3. The annual limits for SZC are those proposed by NNB GenCo (SZC) in their application and are the same as those we have proposed in the draft permit (Table 1). In the draft permit, as well as limits for specific radionuclides, there are two radionuclide groups for which we have set limits. One for “Noble gases” and one for 'beta emitting radionuclides associated with particulate matter'. Table 1 shows the radionuclides we used in our assessment alongside the proposed permit limits.

NNB GenCo (SZC) stated that I-131 makes up 45.6% of the total radioiodine discharged to atmosphere. As we have chosen to set a limit for I-131 and not a limit for ‘total iodines’, we included discharges of I-133 in our assessment to represent other isotopes making up the total radioiodine discharge. The quantity of I-133 discharged was based on the assumption that other isotopes of radioiodine contribute an additional 119% (54.5 ‘other iodines’/45.6 ‘I-131’) of the permitted limit on discharges of I-131.

For SZB the discharges to atmosphere used in our assessment, based on permitted limits, are presented in Table 2. Permitted limits are set for H-3, C-14, I-131 and the aggregated groups 'noble gases' and 'particulate beta' (Environment Agency et al, 2019). At the point we were undertaking our assessment we were aware of a permit variation submitted by SZB to increase their C-14 limit to 600 GBq per year (this increased limit was subsequently granted in September 2021) and therefore we decided to use the proposed C-14 limit for SZB to ensure our assessment was robust. Following discussion with the SZB site operator, we determined that noble gases should be represented by Kr-88, rather than Ar-41 which was used in the NNB GenCo (SZC) assessment (NNB GenCo (SZC), 2020b). The group 'particulate beta' is represented by Co-60.

Two source terms are used for the SZA discharges to atmosphere, one based on the permitted limits and the other on actual discharges recorded for 2018 (Environment Agency et al, 2019). In both cases levels are given for H-3, C-14 and 'Beta' (Table 3). The aggregated beta category is assumed to be comprised of Co-60 and Cs-137 (Smith et al, 2002).

Table 1 Discharges to atmosphere from Sizewell C

Proposed radionuclide or group	Proposed limit (Bq y^{-1})	Radionuclide assessed	Discharges used in the assessment (Bq y^{-1})
C-14	1.40 10^{12}	C-14	1.40 10^{12}
Beta emitting radionuclides associated with particulate matter	1.20 10^{8}	Co-58	3.06 10^{7}
Beta emitting radionuclides associated with particulate matter	1.20 10^{8}	Co-60	3.61 10^{7}
Beta emitting radionuclides associated with particulate matter	1.20 10^{8}	Cs-134	2.81 10^{7}
Beta emitting radionuclides associated with particulate matter	1.20 10^{8}	Cs-137	2.52 10^{7}
H-3	6.00 10^{12}	H-3	6.00 10^{12}
I-131	4.00 10^{8}	I-131	4.00 10^{8}
N/A	N/A	I-133#	4.77 10^{8}
Noble gases	4.50 10^{13}	Ar-41	1.31 10^{12}
Noble gases	4.50 10^{13}	Kr-85	6.26 10^{12}
Noble gases	4.50 10^{13}	Xe-131m	1.35 10^{11}
Noble gases	4.50 10^{13}	Xe-133	2.84 10^{13}
Noble gases	4.50 10^{13}	Xe-135	8.92 10^{12}

#The assessment allowed for expected discharges of I-133 which represents other isotopes of radioiodine.

Table 2 Discharges to atmosphere from Sizewell B

Radionuclide	Annual permitted discharges in 2018 (Bq y^{-1})
H-3	$3.00\ 10^{12}$
C-14	$6.00\ 10^{11}$*
I-131	$5.00\ 10^{8}$
Kr-88 (noble gases)	$3.00\ 10^{13}$
Co-60 (particulate beta)	$1.00\ 10^{8}$

*The SZB limit when the assessment took place was $5.00\ 10^{11}$ but an application to vary the limit to $6.00\ 10^{11}$ had been received (and was subsequently granted) by the Environment Agency in September 2021.

Table 3 Discharges to atmosphere from Sizewell A

Radionuclide	Annual permitted discharges in 2018 (Bq y^{-1})	Radionuclide (Bq y^{-1})
H-3	$3.50\ 10^{12}$	$2.64\ 10^{10}$
C-14	$1.00\ 10^{11}$	$8.82\ 10^{8}$
Co-60 (beta)	$1.92\ 10^{8}$	$4.40\ 10^{3}$
Cs-137 (beta)	$6.58\ 10^{8}$	$1.51\ 10^{4}$

3.1.2. Atmospheric dispersion modelling

Radionuclides discharged to the atmosphere from the Sizewell sites undergo dispersion and subsequent accumulation in the environment. For normal operations, where it can be assumed that discharges are continuous and constant throughout each year of operation, these processes were modelled using PC-CREAM 08, which is described in detail in HPA-RPD-[5]8 (Smith and Simmonds, 2009). For atmospheric discharges the models used in PC-CREAM 08 include: PLUME, to model atmospheric dispersion and deposition; GRANIS, to model external exposure to radionuclides deposited on the ground; FARMLAND, to model uptake of radionuclides into food; and RESUS, to model the resuspension of radionuclides into the atmosphere. Where possible we used site-specific data as input to the models to better represent the dispersion conditions around the Sizewell site (Tables A3.1 and A3.2, of Appendix 3). The exposure pathways we considered are:

- Inhalation of and external exposure to the radioactive plume
- External exposure to radionuclides deposited on the ground
- Ingestion of radionuclides in terrestrial foods
- Inhalation of radionuclides resuspended into the air

The PLUME model is based on the Gaussian approach as described in NRPB-R91 (Clarke, 1979). PLUME can be used to calculate activity concentrations in air, deposition rates and cloud gamma dose rates at locations of interest surrounding the discharge point using a specified annual discharge rate. PLUME does not model the effects of plume rise or downwash from nearby buildings on the dispersing plume. However, where necessary, these processes can be taken into account by using an effective stack height. For this assessment, effective stack heights were based on the approach described in NRPB-W16 (Walsh and Jones, 2002) in which a third of the height of the most dominant building is used. For SZC this building is 60 m high and therefore an effective stack height of 20 m was used for both stacks.

PLUME models the dispersion of radionuclides under different meteorological conditions. The Pasquill stability category scheme is used to group the meteorological conditions into seven categories of increasing atmospheric stability, namely A to F. The results of the PLUME model for each stability category are then weighted by the frequency with which those categories occur in each wind direction around the site and the frequency with which the wind blows in each direction. In this way, annual average air concentrations and deposition rates around the site can be calculated. The meteorological data for the site were derived from the Met Office numerical weather prediction (NWP) model for the years 2015 to 2019. These data were processed for use in PC-CREAM 08 and the corresponding site windrose is presented in Figure 3. The windrose shows the frequency with which the wind blows in each direction and the frequency with which each stability category occurs in each direction. Further details of the modelling carried out and the processing of meteorological data are given in Appendix 3. Results of the dispersion modelling for expected SZC discharges are presented in Appendix 4.

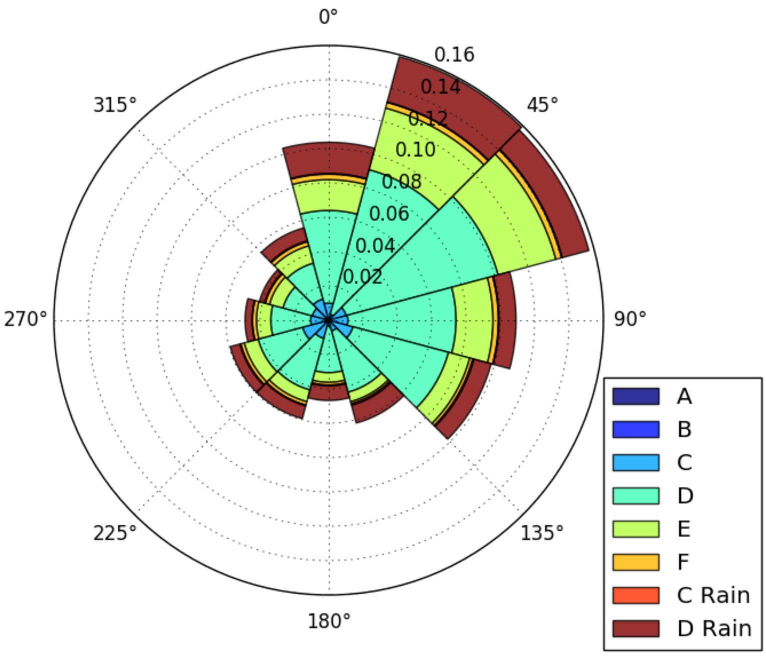

Figure 3 Wind rose from site-specific meteorological data for 2015 to 2019 at Sizewell (wind directions indicate direction towards which the wind is blowing)

3.2. Liquid discharges

This section describes the modelling of routine liquid discharges proposed as part of the normal operation of SZC and currently occurring as part of the operation of SZB and the decommissioning of SZA. We considered discharges at the proposed permit levels for SZC, and the current permit limits for SZA and SZB. In addition recent discharge data have also been considered for SZA. The aim of the modelling exercise is to calculate the spatial and temporal distribution of environmental activity concentrations that arise following dispersion and accumulation of radionuclides released to the marine environment.

3.2.1. Source term

Proposed liquid discharges for SZC are presented in Tables 4 to 6. The annual limits for SZC were proposed by NNB GenCo (SZC) (Table 4) and are the same as those we have proposed in the draft permit. The draft permit includes specific limits for H-3, C-14, Co-60, Cs-137 and a grouped limit for 'other radionuclides'. The radionuclides and distribution we used to represent the 'other radionuclides' group is consistent with that used by the applicant in their assessment.

For SZB, liquid discharges are presented in Table 5. SZB has permitted limits for H-3, Cs-137 and the aggregated group 'other radionuclides' (Environment Agency et al, 2019). Other radionuclides are represented by Cs-134 which is consistent with a previous radiological impact assessment for SZB (Environment Agency, 2006) and the assessment provided by the applicant (NNB GenCo (SZC), 2020b).

Two source terms are used for SZA liquid discharges, one based on permitted limits and the other on actual discharges recorded for 2018 (Environment Agency et al, 2019). In both cases levels are given for H-3, Cs-137 and 'other radionuclides' (Table 6). The aggregated 'other radionuclides' category is assumed to be comprised of S-35, Ca-45, Fe-55, Co-60, Sr-90, Y-90 and Cs-134.

Table 4 Liquid discharges from Sizewell C

Radionuclide or group	Proposed limit (Bq y^{-1})	Radionuclide assessed	Discharges used in the assessment (Bq y^{-1})
H-3	$2.00\ 10^{14}$	H-3	$2.00\ 10^{14}$
C-14	$1.90\ 10^{11}$	C-14	$1.90\ 10^{11}$
Co-60	$6.00\ 10^{9}$	Co-60	$6.00\ 10^{9}$
Cs-137	$1.90\ 10^{9}$	Cs-137	$1.90\ 10^{9}$
Other radionuclides	$1.20\ 10^{11}$	Cr-51	$1.18\ 10^{8}$
Other radionuclides	$1.20\ 10^{11}$	Mn-54	$5.31\ 10^{8}$

Radionuclide or group	Proposed limit ($Bq\ y^{-1}$)	Radionuclide assessed	Discharges used in the assessment ($Bq\ y^{-1}$)
Other radionuclides	$1.20\ 10^{11}$	Co-58	$4.07\ 10^{9}$
Other radionuclides	$1.20\ 10^{11}$	Ni-63	$1.89\ 10^{9}$
Other radionuclides	$1.20\ 10^{11}$	Ag-110m	$1.12\ 10^{9}$
Other radionuclides	$1.20\ 10^{11}$	Te-123m	$5.11\ 10^{8}$
Other radionuclides	$1.20\ 10^{11}$	Sb-124	$9.63\ 10^{8}$
Other radionuclides	$1.20\ 10^{11}$	Sb-125	$1.60\ 10^{9}$
Other radionuclides	$1.20\ 10^{11}$	I-131	$9.83\ 10^{7}$
Other radionuclides	$1.20\ 10^{11}$	Cs-134	$1.10\ 10^{9}$

Table 5 Liquid discharges from Sizewell B

Radionuclides	Annual permitted discharges in 2018 ($Bq\ y^{-1}$)
H-3	$8.00\ 10^{13}$
Cs-137	$2.00\ 10^{10}$
Cs-134 (other radionuclides)	$1.30\ 10^{11}$

Table 6 Liquid discharges from Sizewell A

Radionuclide	Annual permitted discharges in 2018 ($Bq\ y^{-1}$)	Annual actual discharges in 2018 ($Bq\ y^{-1}$)
H-3	$5.00\ 10^{12}$	$3.50\ 10^{10}$
Cs-137	$1.00\ 10^{12}$	$1.09\ 10^{11}$
S-35 (other radionuclides)	$7.00\ 10^{10}$	$6.69\ 10^{9}$
Ca-45 (other radionuclides)	$2.80\ 10^{10}$	$2.68\ 10^{9}$
Fe-55 (other radionuclides)	$2.80\ 10^{10}$	$2.68\ 10^{9}$
Co-60 (other radionuclides)	$1.40\ 10^{10}$	$1.34\ 10^{9}$
Sr-90 (other radionuclides)	$3.50\ 10^{11}$	$3.35\ 10^{10}$
Y-90 (other radionuclides)	$1.40\ 10^{11}$	$1.34\ 10^{10}$
Cs-134 (other radionuclides)	$7.00\ 10^{10}$	$6.69\ 10^{9}$

3.2.2. Marine dispersion modelling

Radionuclides released to the sea from the Sizewell sites will undergo dispersion and subsequent accumulation in the marine environment. For normal operations, where it can be assumed that discharges are continuous and constant throughout each year of operation, these processes were modelled using PC-CREAM 08 which is described in detail in HPA-RPD-58 (Smith and Simmonds, 2009). The marine dispersion model included in PC-CREAM 08, DORIS, is based on the compartmental model developed under the MARINA II project (European Commission, 2002). DORIS models dispersion in the marine environment using a set of interconnected compartments where each compartment represents a different sea region. The movement of radionuclides between compartments is modelled using rate constants which represent the fraction of water, and associated radionuclides, transferred from one compartment to another in unit time. The rate constants are derived from an understanding of the behaviour of marine tides and currents. A fundamental assumption in the model is that radionuclides entering a compartment are immediately dispersed uniformly throughout the compartment. As a consequence, it is common practice to define a relatively small local compartment around the discharge point to ensure that the level of dilution around that point is not excessive. Such a local compartment can also be parameterized to better represent dispersion conditions near to the source. In this assessment the local compartment parameter values for Sizewell were changed from the defaults used in PC-CREAM 08 v1.5.1.92/2.0.0 and are based on a recent review of UK coastal sites (Smith, 2019). The site-specific data we used as input to the DORIS model are presented in Table A3.5, Appendix 3. DORIS can be used to calculate activity concentrations in filtered and unfiltered seawater, sediments suspended in the water column, bed sediments and marine foodstuffs (Appendix 4). The exposure pathways considered are:

- External exposure from radionuclides in marine sediments
- External exposure from radionuclides in sediment on fishing equipment
- Ingestion of radionuclides in marine foods (fish, molluscs, crustaceans and seaweed)
- Inhalation of radionuclides in seaspray (not included in CEFAS habits profiles)

In DORIS, the ingrowth of radioactive progeny is explicitly modelled for all the members of the decay chain that cannot be considered to have reached secular equilibrium after one year. Other radioactive progeny are assumed to have the same level of environmental activity as the parent.

Some of the exposure pathways included in the CEFAS survey for the marine environment are not modelled in PC-CREAM 08. These are immersion in seawater and consumption of wildfowl. Immersion in seawater was modelled using activity concentrations in unfiltered water from DORIS and dose coefficients for immersion in water from FGR15 (US EPA, 2019). Consumption of wildfowl combined activity concentrations in filtered water from DORIS with activity concentration ratios for marine birds from ERICA (Brown et al, 2016). Further details are given in Appendix 3.

3.3. Doses to candidates for representative person for SZC

A prospective dose assessment was carried out in accordance with guidance from ICRP (ICRP, 2006) and EA (Environment Agency et al, 2012). Individual effective doses received in the 60th year of operation of SZC were calculated for the habits profiles presented in the CEFAS habit survey (Garrod et al, 2016). The exposure pathways considered in the CEFAS survey were mapped to those in PC-CREAM 08 to identify gaps and requirements for additional modelling approaches (Tables A3.9 and A3.10, Appendix 3). The receptor locations used for each habits profile were determined based on the arguments laid out in Section 2.2. The habits profiles from the CEFAS survey were considered candidates for the representative person (CRP) at SZC. The representative person (RP) is an individual who represents those members of the community who are likely to receive the highest doses as a result of normal operations at SZC. This section summarises the doses calculated to the CRPs based on expected discharges from SZC only. These doses are used to identify the RP and, in Section 6, are combined with doses from SZA and SZB, direct shine from SZC and short-term discharges from SZC to obtain the total dose to the RP.

A set of spreadsheets was used to calculate the required individual doses. These spreadsheets use dose per unit release data, normalised by habits, which are then scaled by the actual releases and habit data. The ASSESSOR module in PC-CREAM 08 was used to calculate doses per unit release rate for each exposure pathway. The input data used in ASSESSOR are given in Tables A3.7 and A3.8 of Appendix 3. For exposure pathways not included in PC-CREAM 08, e.g. consumption of wild foods, other methods were used to derive doses per unit release rate (Appendix 3).

The CEFAS habit survey for 2015 (Garrod et al, 2016) includes data for 28 different habits profiles and each one is comprised of one or more age groups, i.e. adults, children, infants and women of child bearing age. Doses were calculated to all profiles for both discharges to atmosphere and liquid discharges to identify those receiving the highest exposures.

Doses to the profiles receiving the highest exposures are given in Table 7.1 and Table 7.2; their habit data are presented in Table A3.11, Appendix 3, and the habit locations in Table A1.1, Appendix 1.

The highest annual effective dose from 60 years of operation of SZC was calculated to be 3.8 µSv for adult sea fish consumers. This group is therefore identified as the RP for SZC and is used in the calculation of total dose from all Sizewell site sources in Section 6 (Tables 10 and 11). Most of this dose (92%) comes from the ingestion of C-14 in sea fish. For children, the highest dose was 3.7 µSv for mollusc consumers with most of the dose (94%) also coming from the ingestion of C-14 in sea fish. For infants, the highest dose was 3.0 µSv for sea fish consumers and, again, most of the dose (99%) is from the ingestion of C-14 in sea fish. A breakdown of doses to the RP and selected CRPs is presented in Appendix 5.

The group most exposed to discharges to atmosphere was found to be the 'Adult Plume IN (0-0.25 km)' group, i.e. for adults spending significant amounts of time in the inner zone of the direct radiation survey area. The highest annual effective dose to members of the 'Adult Plume IN (0-0.25 km)' group was calculated to be 2.8 µSv. The greatest contributions to this dose are from inhalation of C-14 (40%) and ingestion of C-14 in sea fish (40%). For children, the highest dose is $9.0\ 10^{-1}$ µSv for the 'Child Plume 0.5-1 km' group but most of the dose (65%) is from the ingestion of C-14 in sea fish and only 5% is from inhalation of C-14. For infants, the highest dose is $8.3\ 10^{-2}$ µSv for 'Infant Green veg consumers' and almost all of this dose is from ingestion of C-14 in fruit and vegetables.

Doses to the fetus from SZC discharges were also calculated based on HPA guidance (HPA, 2008). Of the radionuclides included in the SZC atmospheric and liquid source terms, H-3, C-14 and I-131 warrant special consideration for the fetus. Calculations were performed for ingestion pathways only and used habits profile data for women of childbearing age (WOCBA). The dose to the fetus was calculated by scaling the dose to WOCBA using the ratio of the ingestion dose coefficients. For H-3, C-14 and I-131 the fetal dose coefficients are all higher, with ratios of 3.5, 1.4 and just greater than 1.0, respectively. Although other radionuclides and exposure pathways were not included, a comparison was made between the fetal ingestion dose and that of the RP for the radionuclides considered. For the fetus, the highest doses were calculated for WOCBA who ate crustaceans. This profile group had no exposure to discharges to atmosphere. The contributions to the dose to the RP from ingestion of seafood are 3.6 µSv for C-14, $6.3\ 10^{-3}$ µSv for H-3 and $6.8\ 10^{-6}$ for I-131. Doses to the fetus for the same radionuclides are similar: 2.9 µSv for C-14, $6.3\ 10^{-3}$ µSv for H-3 and $4.1\ 10^{-6}$ µSv for I-131. Given the overwhelming contribution of ingestion of C-14 to the total dose for all age groups, it can be inferred that the total dose to the fetus is similar to that of the RP.

Table 7.1 Annual effective dose (µSv) in 60th year to selected CRPs from SZC discharges. For each age group doses given are for the profiles receiving the highest exposure to discharges to atmosphere.

Age group	CRP	Discharges to atmosphere	Liquid discharges	Total
Adult	Plume IN (0 to 0.25 km)	$1.4\ 10^{0}$	$1.3\ 10^{0}$	$2.8\ 10^{0}$
Child	Plume MID (0.5 to 1 km)	$8.4\ 10^{-2}$	$8.2\ 10^{-1}$	$9.0\ 10^{-1}$
Infant	Green veg consumers	$8.3\ 10^{-2}$	0	$8.3\ 10^{-2}$

Table 7.2 Annual effective dose (µSv) in 60th year to selected CRPs from SZC discharges. For each age group doses given are for the profiles receiving the highest exposure to liquid discharges.

Age group	CRP	Discharges to atmosphere	Liquid discharges	Total
Adult	Sea fish consumers	$6.2\ 10^{-2}$	$3.7\ 10^{0}$	$3.8\ 10^{0}$
Child	Mollusc consumers	0.0	$3.7\ 10^{0}$	$3.7\ 10^{0}$
Infant	Sea fish consumers	0.0	$3.0\ 10^{0}$	$3.0\ 10^{0}$

The highest dose is to adult member of sea fish consumers group and hence this group is identified as the RP.

4. Doses from direct radiation

The calculation of doses to members of the public exposed to direct radiation from the Sizewell site is based on the approach described in the NNB GenCo (SZC) Sizewell C assessment (NNB GenCo (SZC), 2020b) and is summarised in Appendix 6. NNB GenCo (SZC) assume that doses from exposure to direct radiation from the reactor building will be negligible because of the high level of shielding and that the majority of the dose will come from the Interim Spent Fuel Store (ISFS) and Intermediate Level Waste Storage (ILWS) facilities on site. However, the designs of the ISFS and ILWS have yet to be finalised and therefore there is limited detailed information regarding the source terms (dose rate) for direct shine. Therefore, the approach used by NNB GenCo (SZC), and adopted here, was to assume a maximum permissible dose rate close to the source buildings and extrapolate these to the receptor locations of interest (Appendix 6). The locations of the ISFS and ILWS are presented in Table A6.1 of Appendix 6 and are based on information provided in the NNB GenCo (SZC) permit application head document (NNB GenCo (SZC), 2020a). During our permit determination NNB GenCo (SZC) proposed some minor changes to the location of the ISFS and ILWS buildings from the site plan provided in the application. NNB GenCo (SZC) provided us with an assessment of the impact of this change on direct doses to members of the public. We reviewed the assessment completed by NNB GenCo (SZC) and considered the impacts on direct dose from these changes to be negligible hence we did not look to revise our assessment.

The NNB GenCo (SZC) assessment report (NNB GenCo (SZC), 2020b) identifies three possible candidates for members of the public most exposed to direct radiation. These are people who spend time walking the footpaths around the north and east side of the proposed development (e.g. a dog walker), a resident in a nearby property and a worker on the Sizewell B site. We considered these three groups in addition to four CRP profiles from the Sizewell habit survey (Garrod et al, 2016) in our assessment. We selected the three habits profiles that represent those individuals most exposed to direct radiation and also the RP identified in Section 3.3. Details of the individuals considered are discussed below and summarised in Table A6.1, Appendix 6.

The NNB GenCo (SZC) assessment concluded that the only significant source of direct radiation to a user of the footpaths is the ILWS facility. The distance of the dog walker from the facility will vary as they walk the path; for simplicity of calculation the dog walker was placed at the nearest point to the facility on the public footpath, approximately 190 m from the ILWS facility, for 30 minutes (the time taken to walk a 2.5 km stretch of path at 5 km h^{-1}).

The nearest residential area is the hamlet of Sizewell. Sizewell A and B are currently both in the direct line of sight between Sizewell hamlet and the proposed Sizewell C facility, but in the future both these older facilities may be demolished, or a new residential development constructed to the north-east of the site. For this assessment, the resident of a nearby property was placed around 1 km in direct line of sight of the ILWS facility and the ISFS. The resident was assumed to spend all their time at home, 90% of which was spent indoors.

The assessment to a Sizewell B worker was based on information provided in the NNB GenCo (SZC) assessment report. It was assumed that this worker spends 2000 h y^{-1} on the Sizewell B site located 150 m from ISFS and 477 m from the ILWS facility and that 50% of their time was spent indoors. No dose was calculated for the time this person is not at work.

The assessment of direct radiation dose to the 'Adult Plume IN (0 to 0.25 km)', 'Adult Plume MID (0.25 to 0.5 km)', 'Adult Plume OUT (0.5 to 1 km)' and 'Adult Sea fish consumers' groups used the occupancy data for these profiles given in (Garrod et al, 2016). The occupancies and assumed locations of these profiles are presented in Table A6.1 of Appendix 6.

The data used in the assessment of doses to the public from direct shine are presented in Appendix 6, Table A6.1. The contribution from skyshine, i.e. indirect external exposure to radiation emitted from the source and scattered from the atmosphere back to the ground, is also considered in Appendix 6 and the working assumption is that it is comparable to the direct shine dose. Table 8 shows the annual dose from direct shine to all the groups considered in this section. The dose to 'Adult Sea fish consumers' was added to the total dose to the RP (see Section 6).

Table 8 Annual doses (μSv) from direct radiation (not including skyshine)

CRP	Annual direct radiation dose (μSv) from Interim spent fuel store	Annual direct radiation dose (μSv) from Intermediate level waste store	Annual direct radiation dose (μSv) Total
Dog walker	-	$4.8\ 10^{-1}$	$4.8\ 10^{-1}$
Resident	$8.3\ 10^{-4}$	$8.3\ 10^{-4}$	$1.7\ 10^{-3}$
Sizewell B worker	$3.7\ 10^{0}$	$2.4\ 10^{-3}$	$3.7\ 10^{0}$
Adult Plume IN (0 to 0.25km) (CRP)	$1.1\ 10^{0}$	$2.3\ 10^{-3}$	$1.1\ 10^{0}$
Adult Plume MID (>0.25 to 0.5 km) (CRP)	$5.4\ 10^{-4}$	$3.8\ 10^{-4}$	$9.2\ 10^{-4}$
Adult Plume OUT (>0.5 to 1 km) (CRP)	$2.3\ 10^{-4}$	$1.8\ 10^{-4}$	$4.1\ 10^{-4}$
Adult Sea fish consumers (RP)	$1.6\ 10^{-1}$	$3.9\ 10^{-4}$	$1.6\ 10^{-1}$

5. Doses from short-term discharges

Short-term discharges to atmosphere may occur during the normal operation of Sizewell C (SZC). Such discharges may occur during reactor start-up or shut-down and lead to larger than average releases over relatively short periods of time. The discharges must not exceed the permitted limits but may occur in conjunction with other factors, such as poor dispersion conditions, and lead to enhanced doses to the public hence we undertook a specific assessment of the impact of short-term discharges to atmosphere.

There is no requirement to model the impact of short-term liquid discharges to the marine environment for two key reasons: significant short-term liquid discharges are unlikely to occur as liquid discharges are held in storage tanks before release and follow a semi-continuous release process and there are considerable dilution effects in the marine environment caused by currents and tides (NDAWG, 2020).

5.1. Short-term atmospheric discharges

NNB GenCo (SZC) reports (NNB GenCo (SZC), 2019) that short-term atmospheric discharges are unlikely to occur from both SZC stacks at the same time and therefore the assessment was performed for a single stack.

We considered doses from short term atmospheric discharges for the groups we identified as being most exposed to continuous aqueous and atmospheric discharges (‘adult sea fish consumers’, ‘child mollusc consumers’, ‘infant sea fish consumers’ and ‘adult plume IN (0 to 0.25 km), Tables 7.1 and 7.2).

We calculated annual effective doses received from exposures arising in a 12 month period following the short-term release.

5.1.1. Source term

We primarily used the source term for short-term discharges to atmosphere from SZC provided by NNB GenCo (SZC) in their application (NNB GenCo (SZC), 2020b) (Table 9). NNB GenCo (SZC) assumed a release duration of 24 hours, whereas in this assessment we used a 12 hour release duration to maintain consistency with NDAWG guidance (NDAWG, 2020) and the NRPB-W54 methodology (Smith et al, 2004) (see Section 5.1.2).

To support our decision on whether to set any Weekly Advisory Limits (WALs) we also made an assessment of the impact should the maximum proposed annual limits be discharged over the same short period of 12 hours.

Table 9 Expected short-term discharges to atmosphere from SZC

Radionuclide	Total release in 12 hours (Bq)	Emission rate over 12 hours (Bq s^{-1})
Ar-41	1.09 10^{11}	2.5 10^{6}
C-14	1.17 10^{11}	2.7 10^{6}
Co-58	9.08 10^{5}	2.1 10^{1}
Co-60	1.07 10^{6}	2.5 10^{1}
Cs-134	8.32 10^{5}	1.9 10^{1}
Cs-137	7.46 10^{5}	1.7 10^{1}
H-3	5.00 10^{11}	1.2 10^{7}
I-131	3.33 10^{7}	7.7 10^{2}
I-133	6.45 10^{6}	1.5 10^{2}
Kr-85	5.22 10^{11}	1.2 10^{7}
Xe-131m	1.13 10^{10}	2.6 10^{5}
Xe-133	2.37 10^{12}	5.5 10^{7}
Xe-135	7.43 10^{11}	1.7 10^{7}

5.1.2. Atmospheric dispersion modelling

PC-CREAM 08 is not designed to model short-term releases. Therefore the Atmospheric Dispersion Modelling System (ADMS 4.2) (CERC, 2010) was used following guidance provided by NDAWG (NDAWG, 2020) and the methodology described in NRPB-W54 (Smith et al, 2004). The NDAWG guidance includes pre-calculated dose per unit release data which are based on specific dispersion scenarios. For this assessment, doses per unit release were recalculated specifically for SZC using site-specific information such as meteorological data. The Atmospheric Dispersion Modelling System (ADMS 4.2) (CERC, 2010) was then used to calculate activity concentrations in air, deposition rates and cloud gamma dose rates per unit release rate. ADMS was used in continuous plume release mode, rather than in discrete puff release mode, with hourly sequential meteorological data. We used the continuous plume mode because the puff model outputs for time integrated results are the same as the equilibrium results for the continuous plume model. This is because the puff model assumes that the same hourly meteorological conditions apply to the whole release duration of the puff even if it is longer than 1 hour. Using ADMS 4.2 in plume mode means that it can also be used to calculate cloud gamma dose rates.

It is not possible to use the buildings module with the cloud gamma model in ADMS 4.2. Therefore, the impact of buildings on the dispersing plume was taken into account by using an effective stack height equal to one third of the dominant building height as recommended in NRPB-W16 (Walsh and Jones, 2002). ADMS 4.2 automatically considers stack downwash and plume rise but for this assessment these were disabled as the dominant effect on the plume, downwash due to the nearby building, is already taken into account by using an effective stack height.

The meteorological conditions at the time of a short-term release may have a significant impact on dispersion and the subsequent doses. To assess this impact, we ran ADMS 4.2 using hourly sequential meteorological data covering the summer months of the 5 year period 2015 to 2019. Meteorological data for the summer months were used because this is when most crops for human consumption are harvested and so a release at this time of year would lead to the highest levels of activity in food. We calculated results for a single location 500 m from the discharge stack in the prevailing wind direction, i.e. 30° clockwise from north. Assuming 500 m from the release point as the receptor location is a relatively cautious assumption for the assessment. The location selected is closer to the release point than the food production locations used in the continuous release assessments, but is still representative of an area large enough to support the required levels of agricultural production and consumption.

The short-term statistics and rolling 12 hour averages were used to identify the 12 hour period giving rise to the 97.5 percentile of the activity concentration of Cs-137 in air at the location of interest. This 12 hour period of meteorological data was then combined with the SZC source term to calculate activity concentrations in air, deposition rates and cloud gamma dose rates for input to the dose assessment. The input parameters used for ADMS 4.2 are given in Table A7.1 of Appendix 7.

5.2. Doses

A modified spreadsheet tool, previously developed as part of the methodology for NRPB-W54 (Smith et al, 2004), was used with ADMS 4.2 output to calculate doses per unit release, normalised by habits. The dose per unit release data were scaled by the discharge and habit data to calculate doses from the following exposure pathways:

- Inhalation of and external exposure to radionuclides in the plume
- External exposure to gamma radiation from radionuclides deposited on the ground
- Ingestion of radionuclides in terrestrial foods
- Inhalation of radionuclides resuspended into the air

Doses were calculated to individuals living at and obtaining food from a location 500 m from the discharge point in the direction of the prevailing wind. Details of the habit data used to calculate these doses are presented in Table A7.3 of Appendix 7.

The assessment and resulting doses apply equally to a short-term release occurring from stack A or stack B of SZC. Details of the data used in this dose calculation, including intermediate results from ADMS 4.2 (Table 7.4) and foodchain models (Table A7.5), are provided in Appendix 7.

Doses indicative of those received by the RP 'adult sea fish consumers' and the CRPs 'child mollusc consumers', 'infant sea fish consumers' and 'adult plume IN (0 to 0.25 km)' from a short-term release were calculated to be 5.9 10^{-1} µSv, 4.6 10^{-1} µSv, 3.8 10^{-1} µSv and 5.7 10^{-1} µSv respectively. In each case, more than 60% of the dose comes from direct inhalation of C-14 in the dispersing plume.

It should be noted that no data are recorded in the CEFAS study (Garrod et al, 2016) for ingestion of terrestrial foods for 'child mollusc consumers' and 'infant sea fish consumers' and therefore no doses for these pathways were calculated. Doses based on more generic ingestion rates are reported in our consideration of uncertainty and variability in Section 9.

In Tables A7.6 to A7.12 of Appendix 7, doses are broken down by radionuclide and pathway.

In line with our limit setting guidance (Environment Agency, 2010), we also made an assessment of the impact should the entire proposed annual limit be discharged over the same short period of 12 hours. As the source term used in our short-term assessment is based on a release of one month's discharges over 12 hours, the resultant doses can be multiplied by 12 to give an assessment of impact should the proposed annual limit be discharged over 12 hours. We performed this calculation and found that the doses would still remain less than the source constraint (300 µSv).

Further to this, we also compared the activity concentrations in food following a short-term release at the annual limits with the Maximum Permitted Limits (MPLs) set out in Euratom Regulation 2016/52.

The method we used to calculate doses from short-term discharges used activity concentrations in food integrated over 1 year following a release. It is not possible to directly compare these values to MPLs. Instead, we used activity concentrations in food taken from PHE's Probabilistic Accident Consequence Evaluation (PACE) software (Charnock et al, 2020) and combined them with the deposition rates and activity concentrations in air, calculated using our short-term release assessment methodology above, to calculate peak activity concentrations in food. Table A7.13 of Appendix 7 shows the activity concentrations in foodstuffs calculated in this way. There is no MPL for H-3 or C-14 and the PHE PACE model does not contain data for these radionuclides therefore we have not calculated peak activity concentrations in foodstuffs for H-3 or C-14. All of the activity concentrations in foodstuffs we calculated are well below the relevant MPLs.

6. Doses to the representative person (RP)

In Section 3.3 the RP for Sizewell C (SZC) is identified as a member of the 'adult sea fish consumer' group. This section takes into consideration other sources of radiation (Sizewell A – SZA and Sizewell B - SZB) that the RP might be exposed to and presents an estimate of total dose from the Sizewell site (Tables 10 and 11). The total dose includes the following sources:

- Proposed discharges to atmosphere and liquid discharges from SZC
- Expected short-term discharges from SZC
- Direct radiation from SZC
- Future discharges to atmosphere and liquid discharges and direct radiation from SZA and SZB

- Historic discharges to atmosphere and liquid discharges from SZA and SZB

The methods used to calculate doses from proposed discharges from SZC are described above (sections 3 and 5). Doses arising from future discharges from SZA and SZB are calculated in the same way as described for SZC but using different source terms (Tables 2, 3, 5 and 6) and, for atmospheric discharges, taking account of the different position of the discharge stacks (Table A3.4, Appendix 3). Table 10 shows the doses from future discharges from all three sites which can be compared with the site dose constraint of 500 µSv y^{-1}. For SZA we calculated doses using both the permitted limits and also using recent discharge data. The total dose from future discharges and direct radiation are also presented.

Table 10 Annual effective dose (µSv) to the representative person (adult sea fish consumer) after 60 years of operation (no historic component to dose).

Source	Discharges to atmosphere	Discharges to liquid	Short-term discharges	Total from discharges	Direct radiation *	Total
SZC	$6.2\ 10^{-2}$	$3.7\ 10^{0}$	$5.9\ 10^{-1}$	$4.3\ 10^{0}$	$3.2\ 10^{-1}$	$4.7\ 10^{0}$
SZB	$7.1\ 10^{-2}$	$5.2\ 10^{-1}$	-	$5.9\ 10^{-1}$	-	$5.9\ 10^{-1}$
SZA#	$1.3\ 10^{-2}$	$4.0\ 10^{0}$	-	$4.0\ 10^{0}$	-	$4.0\ 10^{0}$
SZA@	$6.2\ 10^{-5}$	$4.3\ 10^{-1}$	-	$4.3\ 10^{-1}$	-	$4.3\ 10^{-1}$
Sum@	-	-	-	$5.4\ 10^{0}$	-	$5.7\ 10^{0}$
Sum#	-	-	-	$9.0\ 10^{0}$	-	$9.3\ 10^{0}$

*Assumption that dose from skyshine equals dose from direct shine, double the value in Table 8.
SZA discharges at permit limits
@ SZA actual discharges

Doses from historical discharges from SZA and SZB were assessed using averaged data from RIFE-23, RIFE-24 and RIFE-25 (Environment Agency et al, 2018), (Environment Agency et al, 2019), (Environment Agency et al, 2020) (See Appendix 9). Total doses to the Representative Person are summarised in Table 11. The total annual dose received in the 60th year assuming discharges continue at current and proposed permitted levels is calculated to be 28 µSv. Contributions to the dose are from historical discharges from SZA and SZB (68%), future operation of SZC (17%), decommissioning of SZA (14%) and future operation of SZB (2%).

The dose from SZC alone is comprised of 79% from routine liquid discharges, 13% from short-term discharges to atmosphere, 7% from direct shine and less than 1% from discharges to atmosphere.

Table 11 Annual effective dose (µSv) to the representative person at the Sizewell site from future discharges from SZA, SZB and SZC and historic discharges from SZA and SZB

Source	Total$
SZA + SZB historic discharges and direct radiation	19
Future discharges 60th year SZA#+SZB+SZC	9.3
Future discharges 60th year SZA@+SZB+SZC	5.7
Total (future and historic discharges)#	28
Total (future and historic discharges)@	25

$ Dose to adult sea fish consumer
@ SZA actual discharges
# SZA discharges at permit limits

7. Collective doses

Collective doses were calculated for expected discharges to atmosphere and liquid discharges from SZC using PC-CREAM 08 (Smith and Simmonds, 2009). Collective dose is a measure of the total dose received by a population as a consequence of a single year of discharge. The quantity is integrated over time to allow for the exposure of future generations and to take account of the build-up of radionuclides in the environment. There are many uncertainties associated with the calculation of collective dose and as such it should be used with caution. It is often used to compare the relative, rather than absolute, impact of one disposal option to another. For this assessment, collective doses truncated at 500 years were calculated for the UK, European and World populations. In addition, per caput doses were calculated for these populations taking into account population size. Per caput doses provide an indication of average annual doses.

7.1. Assessment methodology

The radionuclide source terms and dispersion models used to calculate collective doses are the same as those used for the continuous release assessments described in Section 3. Collective dose calculations also make use of global circulation models to calculate long term exposures from those radionuclides that are long-lived and become globally dispersed. For SZC the radionuclides which warranted this kind of assessment were H-3, C-14 and Kr-85.

The methodology for the collective dose calculation we used is described in HPA-RPD-58 (Smith and Simmonds, 2009). This method does not use individual habit data but instead uses population distributions, agricultural production and seafood catch data held in the PC-CREAM 08 database.

For discharges to atmosphere, the population is assumed to be comprised entirely of adults and the population distribution is assumed to be static in space and time, with people spending 90% of their time indoors. The population distribution is combined with modelled activity concentrations in air, deposition rates and dose coefficients to calculate collective doses from inhalation and external exposure to the plume and external exposure to radioactivity on the ground. For ingestion of terrestrial food, the spatial distribution and quantities of food produced are combined with modelled activity concentrations in food and ingestion dose coefficients to calculate collective doses. It is assumed that all the food produced within a region is consumed in that region and that there are no imports or exports of food.

For liquid discharges, the spatial distribution and quantities of seafood catches are combined with modelled activity concentrations in fish, molluscs and crustaceans and with ingestion dose coefficients to calculate collective doses from ingestion of seafood. In addition, generic occupancy rates are used with modelled activity concentrations in sediments and external dose coefficients to calculate external exposures to people spending time on beaches.

The input data specific to the collective dose calculations are presented in Tables A8.1 and A8.2 of Appendix 8.

7.2. Doses

Collective doses truncated at 500 years were calculated for the UK, Europe and World populations for proposed discharges from SZC. A summary of the doses is given in Tables 12a and 12b and 13a and 13b.

Table 12a Discharges to atmosphere

Collective doses (person Sv per year of discharge) truncated at 500 years for SZC discharges to atmosphere

Population	First pass	Global	Total
UK	0.28	0.15	0.43
Europe	2.5#	1.1~	3.6~
World	2.5#	24.6	27.1

#First pass dose using European population up to 3000km from Sizewell
~Uses EU-25 population from Smith and Simmonds 2009

Table 12b Liquid discharges

Collective doses (person Sv per year of discharge) truncated at 500 years for SZC liquid discharges

Population	First pass	Global	Total
UK	0.022	0.013	0.035
Europe	0.13*	0.076*	0.21*
World	0.22	2.1	2.3

*Uses EU-12 population from Smith and Simmonds 2009

Table 13a Discharges to atmosphere

Summary of collective doses (person Sv per year of discharge) and per caput doses (nSv per person per year of discharge) from collective doses truncated at 500 years for SZC discharges to atmosphere

Population	Collective doses total	Per caput
UK	0.43	7.6
Europe	3.6	7.9#
World	27.1	2.7

#Calculated using EU-25 population from Smith and Simmonds 2009

Table 13b Liquid discharges

Summary of collective doses (person Sv per year of discharge) and per caput doses (nSv per person per year of discharge) from collective doses truncated at 500 years for SZC liquid discharges

Population	Collective doses total	Per caput
UK	0.035	0.59
Europe	0.21	0.58*
World	2.3	0.23

*Calculated using EU-12 population from Smith and Simmonds 2009

8. Dose rates to wildlife

8.1. Source term

The source term used for assessment of the impact on wildlife is the same as that used in our assessment of the impact on people described in section 3.1.1 and section 3.2.1, Table 1 and Table 4. The source term is based on the discharge limits requested by NNB GenCo (SZC) in combination with information provided on the expected breakdown of radionuclides within the discharges from the Sizewell C site.

The impact of liquid discharges and discharges to atmosphere at proposed permitted levels from SZC were modelled as described below while the contributions from SZA and SZB discharges were derived from our previous habitats assessment for radioactive substances work completed in 2017 (Allott et al, 2019)

8.2. Dispersion modelling

We calculated environmental activity concentrations at the selected receptor locations using PC-CREAM 08 (Smith and Simmonds, 2009). We used the same PC-CREAM 08 dispersion models and input data as in our assessment of people described in Section 3. The only difference being the locations of the receptor points considered for atmospheric discharges.

The receptor locations selected are based on the wildlife habitats and species requiring protection surrounding the Sizewell site, these are discussed in Section 2.3. Appendix 2 includes locations of the receptor points (Tables A2.3, A2.4 and A2.5), and the derived environmental activity concentrations (Tables A2.8 to Table A2.10 and Table 2.13).

Although no direct discharges to freshwater systems are proposed for SZC, radionuclides could enter the freshwater environment as a result of atmospheric deposition. This exposure pathway is not modelled in PC-CREAM 08 and therefore the approach described in IAEA SRS 19 (IAEA, 2001) was used. Further details of the method used are provided in Appendix 2 and calculated activity concentrations in freshwater bodies are shown in Table A2.12.

8.3. Dose rates to wildlife- Sizewell C discharges

As discussed in section 2.3, the impact on wildlife from ionising radiation is assessed by calculating the absorbed dose rate to the most exposed RO, where the RO is representative of the wildlife being protected. If the dose rate to the most exposed RO is less than the relevant criterion then it is reasonable to assume that the integrity of the habitat and wildlife populations that occupy it will be unaffected.

Absorbed dose rates to wildlife were calculated using the Environmental Risk from Ionising Contaminants: Assessment and Management (ERICA) tool (Brown et al, 2016) and, for noble gases, the 'Ar-Kr-Xe dose calculator' (Vives i Batlle et al, 2015) using environmental activity concentrations derived as described above.

Absorbed dose rates were calculated to wildlife inhabiting three protected sites: Minsmere-Walberswick Heaths and Marshes SSSI, Sizewell Marshes SSSI, and the Outer Thames Estuary SPA (Tables A2.18 to A2.22 of Appendix 2). We selected these sites as they represent those which would be worst affected due to their proximity to the Sizewell C site.

For Minsmere and Sizewell Marshes, assessments were carried out for terrestrial and freshwater habitats, for the Outer Thames Estuary an assessment was carried out for the marine habitat. An assessment for the marine habitat was not conducted for Minsmere as it would have been the same as that for Outer Thames Estuary because both regions are represented by the Sizewell local compartment of the DORIS dispersion model. The closest MCZ to the Sizewell site is the Orford Inshore which is located ~17 km offshore. As the environmental activity concentrations in the Orford Inshore MCZ would be lower than those in the Outer Thames Estuary we did not undertake a specific assessment of the MCZ region.

Our assessment considered all of the default ROs in the ERICA tool including two additional RO's to represent bats and badgers, the parameter values used to define additional badger and bat groups are shown in Tables A2.9 – A2.11.

The highest dose rate to a RO for proposed discharges from SZC was calculated to be 2.3 10^{-1} µGy h^{-1} for freshwater insect larvae occupying Sizewell Marshes. For the 'Minsmere to Walberswick Heaths and Marshes' and 'Outer Thames Estuary' regions the worst affected ROs for proposed SZC discharges were found to be the freshwater insect larvae (9.4 10^{-2} µGy h^{-1}) and the polychaete worm (6.0 10^{-2} µGy h^{-1}), respectively. The dose rates calculated represent the exposure of the RO to a single environment. Exposures from more than one environment have not been added together because it is assumed that each RO remains in a single environment. Actual occupancy rates for different environments are difficult to determine so assuming the RO remains exposed to high local contamination all of the time will capture the worst case scenario.

8.4. Dose rates to wildlife – all permitted discharges

In addition to the dose rates calculated for discharges from SZC, the impact on wildlife of other permitted radioactive discharges, including those from SZA and SZB, were taken into consideration using our previous habitats assessment for radioactive substances work completed in 2017 (Allott et al, 2019). In our habitats report we assessed the impact of all permitted discharges in 2017 on NATURA 2000 sites in England and in each case reported the total dose rate to the worst affected reference organism. The total dose rate was the sum of the dose rates to the worst affected reference organism in the aquatic and terrestrial environments; this is a cautious calculation as these organisms were not necessarily the same.

For the NATURA 2000 site 'Minsmere to Walberswick Heaths and Marshes', the habitats report calculated a total absorbed dose rate to the worst affected organism of 8.1 10^{-1} µGy h^{-1}, and for the 'Outer Thames Estuary' a dose rate of 1.8 µGy h^{-1}. Sizewell Marshes was not considered in the habitats report because it is not a NATURA 2000 site therefore we used the dose rate for 'Minsmere to Walberswick Heaths and Marshes' to represent the likely dose rate to the worst affected organism at Sizewell Marshes from existing discharges.

By summing the dose rates to the ROs from proposed SZC discharges and dose rates from existing discharges we have calculated total dose rates to the worst affected RO at each habitat location considered. Total dose rates are summarised in Table 14. All total dose rates are well below the threshold of 40 µGy h^{-1}, below which we have previously concluded that there will be no adverse effect on the integrity of a NATURA 2000 site (Allott et al, 2019).

Table 14 Absorbed dose rates (μGy h^{-1}) to worst affected reference organism at each wildlife site

Location / reference organism	Sizewell C proposed discharges	Existing discharges - habitats report (Allott et al, 2019)	Total
Sizewell Marshes: freshwater insect larvae	$2.3\ 10^{-1}$	$8.1\ 10^{-1}$ #	$1.0\ 10^{0}$
Minsmere to Walberswick Heaths and Marshes: freshwater insect larvae	$9.4\ 10^{-2}$	$8.1\ 10^{-1}$	$9.0\ 10^{-1}$
Outer Thames Estuary SPA: polychaete worm	$6.0\ 10^{-2}$	$1.8\ 10^{0}$	$1.8\ 10^{0}$

Dose rate for Minsmere to Walberswick Heaths and Marshes

9. Uncertainty and variability

The assessment described in this report is a prospective assessment of future planned discharges from the Sizewell site. As such it is necessary to use models to calculate environmental activity concentrations that are likely to occur in the future. The models and the input data used are set up to provide an estimate of dose that errs on the side of caution. The models used are well established and have been verified and validated, but inevitably incorporate a level of uncertainty because they are approximate representations of complex, real world scenarios. The dose assessment principles document (EA et al, 2012) recommends that where the assessed mean dose to the representative person exceeds 20 μSv y^{-1}, the uncertainty and variability in the key assumptions used for the dose assessment should be reviewed. The dose to the RP from SZC calculated in this study is less than 20 μSv y^{-1} and therefore a detailed uncertainty analysis is not warranted. However, some foods are not currently produced locally i.e. milk and milk products and so using the habits profile approach excludes some ingestion pathways from the assessment. We considered that a comparison of the dose calculated in Section 3, which used the habits profile method, with a more generic approach would be appropriate in order to give some insight into possible ingestion doses should these foods be produced locally in the future.

9.1. Generic assessment

The generic assessment of discharges to atmosphere from SZC was conducted using PC-CREAM 08 with default data. The production of food for ingestion was assumed to occur 500 m to the north of the North Stack. All ingestion pathways in the PC-CREAM 08 model were considered except for grain. For other foods, the top two approach was used, i.e. it was assumed that the two foods giving the highest doses were consumed at critical ingestion rates while other foods were consumed at average ingestion rates. The ingestion rates are based on national habit survey data. Inhalation and external exposures to the plume and the ground were assumed to occur 250 m to the north of the North Stack. It was assumed that individuals spend all their time at this location, 90% of which indoors. PC-CREAM 08 default indoor shielding factors were used.

The generic assessment for liquid discharges from SZC used PC-CREAM 08 with default data except for the local compartment parameters for which the data presented in Table A3.5 of Appendix 3 were used. It was assumed that individuals were exposed to sediments and fishing gear in the local compartment and consumed seafoods at critical rates. All molluscs and crustaceans consumed were assumed to be caught in the local compartment. For sea fish, it was assumed that 10% of the catch was taken from the local compartment and the remainder from the regional compartment.

A summary of the doses calculated using the generic approach is presented in Table 15. The doses calculated for discharges to atmosphere, using the generic habits data, are greater than those calculated for the RP using the habits profile method. The main reason for this is that milk is not produced in the survey area and therefore ingestion of milk and milk products were not included in the main assessment. Also, the RP is a member of the Adult Sea Fish Consumers group for which the CEFAS survey reports values of zero for ingestion of cow meat and sheep meat and lower ingestion rates for vegetables compared to the generic assessment.

For liquid discharges the generic assessment calculates doses similar to those using the habits profile method. In both methods, the main contribution to the dose comes from ingestion of C-14 in seafood. Where there are differences in dose between the generic and habit profile methods for liquid discharges these arise because of differences in ingestion rates of fish for adult sea fish consumers; the rate reported in the CEFAS survey is 23.5 kg y^{-1} while the default value in PC-CREAM 08 is 100 kg y^{-1}. However, this discrepancy is balanced to some extent by the assumption in the habits profile assessment that all sea fish are caught in the local compartment and not just 10% which is the default used in PC-CREAM 08. Molluscs and crustaceans are also consumed at much lower rates in the habits profile assessment. For example, the adult consumption rate for crustaceans is 0.71 kg y^{-1} and for molluscs 0.09 kg y^{-1}, compared to a default of 20 kg y^{-1} for each in PC-CREAM 08.

Using the generic habits data, the total annual dose from routine discharges from SZC to individuals living near the site, was calculated to be 17 µSv, 14 µSv and 17 µSv to an adult, child and infant respectively (Table 15). For comparison, the dose calculated to the RP (adult sea fish consumer) using the more realistic habits profile method was 3.8 µSv. Both these doses are well below the dose constraint which is 300 µSv.

A cautious generic assessment was also conducted for short-term discharges using the approach described in Section 5 and the habit data presented in Table A7.3 of Appendix 7. As for the generic routine discharges assessment both milk and milk products were included and it was assumed that these two foods were consumed at critical rates. The doses received in the 12 months following the short-term release were calculated to be 6.8 µSv, 7.6 µSv and 14.0 µSv to an adult, child and infant, respectively. In each case, most of the dose (>90%) comes from ingestion of C-14 in terrestrial food. If the results of this cautious assessment are combined with those in Table 15 the dose still remains well below the dose constraint of 300 µSv.

Table 15 Annual dose (µSv) from 60 years of discharges from SZC to a member of the public based on a cautious generic dose assessment

Age	Discharges to atmosphere	Liquid discharges	Total
Adult	$9.0\ 10^{0}$	$8.7\ 10^{0}$	$1.7\ 10^{1}$
Child	$9.9\ 10^{0}$	$3.6\ 10^{0}$	$1.4\ 10^{1}$
Infant	$1.7\ 10^{1}$	$1.2\ 10^{0}$	$1.7\ 10^{1}$

10. Summary and conclusions

We have carried out a prospective assessment to calculate doses to candidates for the representative person at SZC using the habits profiles reported in the CEFAS survey of 2015 (Garrod et al, 2016). The doses calculated were annual effective doses received in the 60th year of operation of SZC and include contributions from permitted discharges, short-term releases and direct radiation. The habits profile group receiving the highest dose and thus identified as the representative person was the 'adult sea fish consumers' group. For a prospective dose assessment of this type the annual dose to this group, 4.7 µSv, can be compared to the dose constraint for a single source, 300 µSv. The dose constraint is used to restrict the magnitude of the individual dose from a single source that is subject to the optimisation process. In this case, the dose to the representative person was calculated to be significantly smaller than the dose constraint. The highest doses calculated for other age groups, i.e. child, infant and fetus, were shown to be similar to those of the RP.

Doses to the RP were also calculated for combined discharges from SZC, SZB and SZA. In this case, the annual dose in the 60th year was 9.0 µSv which is significantly smaller than the site constraint of 500 µSv.

The total annual dose to the RP, which includes expected discharges from SZC at permitted limits, short-term releases from SZC, direct shine from SZC and historic and future discharges from SZA and SZB at permitted limits, was calculated to be 28 µSv. This dose can be compared to the dose limit of 1000 µSv y^{-1} which is a legal limit on the dose received by any individual member of the public and should include exposure to all relevant controllable sources. The total dose to the RP was calculated to be more than an order of magnitude smaller than the dose limit. Historical discharges from SZA and SZB make a significant contribution (68%) to the total dose and this would be expected to decrease over time due to dispersion, dilution and radioactive decay.

Variability and uncertainty in the dose assessments was considered by conducting a generic cautious assessments based largely on UK generalised habits data. These assessments were conducted for routine and short-term discharges from SZC and included ingestion of some food groups, such as milk, not included in the approach based on the CEFAS habits survey for the Sizewell site. Using a generic approach, the highest annual effective dose in the 60th year of operation of SZC from routine discharges was calculated to be 18 µSv to adults and the highest annual effective dose in the 12 months following a short-term discharge from SZC was calculated to be 14 µSv to infants. These doses are well below the source dose constraint of 300 µSv y^{-1}. This provides further confidence that future doses to the RP from all sources will not exceed the dose limit.

A radiological impact assessment was carried out for wildlife near the Sizewell site. The diversity of wildlife in terrestrial, freshwater and marine habitats was represented by the

ROs as defined in the ERICA tool (Brown et al, 2016). The absorbed dose rate to the most exposed RO due to the proposed discharges from SZC was calculated to be 2.3 10^{-1} µGy h^{-1}.

Our habitats assessment report for 2017 (Allott et al, 2019) calculated the dose rates to the worst affected RO from current permitted discharges at Natura 2000 sites in the Sizewell area . Summing the dose rates from current permitted discharges and dose rates calculated from to SZC discharges gave a highest total dose rate of 1.8 µGy h^{-1} to the worst affected RO in the Outer Thames Estuary. The total dose at all of the protected sites we considered is below the 40 µGy h^{-1} threshold, below which we have previously concluded that there will be no adverse effects on the integrity of wildlife or their habitats.

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Appendix 1 Locations for human dose assessment

In 2015 CEFAS conducted a habits survey around the Sizewell nuclear site to establish the occupancy rates, consumption rates and activities of people living nearby (Garrod et al, 2016). Key areas most likely to be affected by discharges from Sizewell were identified, namely, the aquatic survey area, the terrestrial survey area and the direct radiation survey area. The survey was based on the habits profiles approach as recommended by NDAWG (NDAWG, 2009). Age groups included Adults (defined as 16 years old and older), Children (6 to 15 years old) and Infants (0 to 5 years old), which are consistent with ICRP's definitions (ICRP, 2006). Habit data for women of childbearing age were also included and used to assess doses to the fetus.

The CEFAS study did not record specific locations associated with the habits profiles and therefore appropriate assumptions had to made to determine the relevant locations for each habit profile. This appendix identifies the locations used in this assessment. In Table A1.1, the exposure pathways used in the CEFAS habit survey (Garrod et al, 2016) are mapped to specific locations. For example, for the purposes of calculating dose from the consumption of eggs it is assumed that all eggs are produced at a local allotment site. Figures A1.1 and A1.2 show the geographical position of each location relative to the Sizewell site.

Table A1.1 Summary of receptor locations chosen for Sizewell C radiological impact assessment for humans

Description	Location*	CEFAS exposure pathways
Marine survey area: Local marine compartment	Sea region adjacent to Sizewell site	Crustaceans Fish – Sea Gamma external – Houseboat Gamma external – Salt marsh Gamma external – Sediments Marine plants Meat – wildfowl Mollusca Occupancy IN water Occupancy ON water

Description	Location*	CEFAS exposure pathways
Terrestrial survey area: Allotments	From SZC south stack 2617 m, 242°	Eggs Fruit – domestic Honey Meat – poultry Vegetables – Green Vegetables – Other Domestic Vegetables – Potatoes Vegetables – Root
Terrestrial survey area: Salt marsh south of Minsmere	From SZC south stack 1341 m, 2.56°	Meat – Cow Meat – Pig Meat – Sheep
Terrestrial survey area: Open Access land	From SZC south stack 1347 m, 246°	Fruit and nuts – Wild Meat – Game Mushrooms
Direct radiation survey area: Shoreline/beach	From SZC south stack 483.7 m, 60.3°	Plume IN (0 to 0.25km) Inhalation and external exposure
Direct radiation survey area: Local housing	From SZC south stack 1157 m, 168°	Plume MID (>0.25 to 0.5km) Inhalation and external exposure
Direct radiation survey area: Leisure facility	From SZC south stack 1749 m, 171°	Plume OUT (>0.5 to 1km) Inhalation and external exposure

* Angles are clockwise from north

Table A1.2 Generic assessment locations chosen for UK radiological impact assessment for humans using generic habits data

Description	Location*	CEFAS exposure pathways
Generic assessment area: Generic location 250 m north of north stack	From SZC south stack 480 m, 0°	Inhalation and external exposure
Generic assessment area: Generic location 500 m north of north stack	From SZC south stack 730 m, 0°	Food production

* Angles are clockwise from north

Figure A1.1 Map of terrestrial survey area

Figure A1.2 Receptor points and stacks

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Appendix 2 Additional data for wildlife dose assessment

Introduction

This appendix provides further information on the habitats and wildlife living in the vicinity of the Sizewell nuclear site. It identifies the reference organisms (ROs) used in the assessment, presents environmental activity concentrations predicted by the PC-CREAM 08 dispersion models and provides information regarding the approach adopted to model dose rates to freshwater biota from atmospheric deposition. Finally, a breakdown of dose rate by radionuclide is presented for SZC discharges.

Habitats and wildlife

Ecological statutory protected sites within 10 km of the Sizewell nuclear site were identified using the Natural England mapping tool (Natural England, 2020). 15 protected sites were listed, of which 9 were designated as such primarily for reasons of biodiversity. These sites are listed below along with a description of the type of habitat, some of the key wildlife and the assessments required.

The assessments required are referred to as:

- T = terrestrial
- F = freshwater
- M = marine

Statutory protected sites within 10km of Sizewell nuclear site

Leiston - Aldeburgh SSSI (overlaps Sandlings SPA) (T, F, M)

Leiston-Aldeburgh contains a rich mosaic of habitats including acid grassland, heath, scrub, woodland, fen, open water and vegetated shingle.

The variety of habitats support a diverse and abundant community of breeding and overwintering birds, a high number of dragonfly species and many scarce plants.

Alde-Ore Estuary SSSI (overlaps Alde, Ore and Butley Estuaries SAC; Alde-Ore Estuary Ramsar; Alde-Ore Estuary SPA; Orfordness - Shingle Street SAC) (T, F, M)

The scientific interests of the site are outstanding and diverse. The site also contains a number of coastal formations and estuarine features including mud-flats, saltmarsh, vegetated shingle and coastal lagoons which are of special botanical and ornithological value.

The botanical interest of this site is significant including many salt marsh species and shingle species.

The site is of national importance for its birdlife. Avocets gadwall, shoveler, oystercatcher, ringed plover, common tern, Arctic tern, sandwich tern and little tern, common gull, short-eared owl, wheatear and marsh harrier. There are also very large breeding colonies of black-headed gull, lesser-black-backed gull and herring gull.

Also home to nationally rare invertebrates.

Gromford Meadow SSSI (T)

Unimproved base-rich marsh on an alluvial soil with a high organic content.

Fen meadow and marshland plants.

Minsmere-Walberswick Heaths and Marshes SSSI (overlaps Minsmere to Walberswick Heaths & Marshes SAC; Minsmere-Walberswick Ramsar; Minsmere-Walberswick SPA; Outer Thames Estuary SPA) (T, F, M)

This site contains a complex series of habitats, notably mudflats, shingle beach, reedbeds, heathland and grazing marsh, which combine to create an area of exceptional scientific interest.

Variety of saltmarsh and shingle plant species.

Tidal mudflats of the River Blyth estuary form sheltered feeding grounds for wildfowl and shorebirds, notably wigeon, shelduck, redshank and dunlin.

Reed beds are home to reed warbler, bearded tit, marsh harrier, bittern, cetti's warbler, garganey and water rail.

The marshes have a rich insect fauna; particularly moths, which includes a number of rare species.

At Minsmere, shallow lagoons are home to wading birds and wildfowl.

Heathland provides a valuable habitat for two nationally decreasing birds, the nightjar and woodlark.

Mature woodlands provide additional habitat diversity for birds and invertebrates.

Potton Hall Fields, Westleton SSSI (T, F)

The site comprises two gently sloping fields with a narrow watercourse running between them. The soils, being derived from glaciofluvial drift, are well drained and sandy.

Contains nationally rare red-tipped cudweed which is protected under the Wildlife and Countryside Act 1981

Sizewell Marshes SSSI (T, F)

Large area of lowland, unimproved wet meadows.

Supports variety of invertebrates, breeding birds and nationally scarce plants.

Snape Warren SSSI (overlaps Sandlings SPA) (T)

Lowland heathland of eastern England.

Includes heather areas with a varied age structure, the latter stages support a variety of lichens and mosses.

The acid grassland present is dominated by common bent and sheep's fescue, heath bedstraw, sheep's sorrel and harebell. Where this grassland adjoins the Alde Estuary, the saline influence can be seen in the presence of species such as bucks-horn plantain and common saltmarsh-grass. The site supports a number of reptile and bird species characteristic of heathland, including common lizard, adder and nightjar

Outer Thames Estuary SPA (M)

Legally underpinned by several separate SSSIs.

Key species include common tern, little tern and red-throated diver.

Southern North Seas SAC (M)

A mix of habitats, such as sandbanks and gravel beds.

This site has been identified as an area of importance for harbour porpoise.

Orford Inshore designated as MCZ in 2019 (~17 km offshore) (M)

Seafloor of mixed sediment.

Extremely important as a nursery and spawning ground for many fish species, including Dover and lemon sole, sprat and sandeel. Skates, rays, small spotted catsharks and several crustacean species.

Foraging seabirds and harbour porpoises.

UK/EU protected species

Flying mammals (bat) and large burrowing mammals (badger) will be considered in assessment.

Protected species include the specific and general groups:

Bats, great crested newts, badgers, hazel or common dormice, water voles, otters, wild birds, reptiles, protected plants, white-clawed crayfish, mussels, invertebrates, freshwater fish, natterjack toads, ancient woodland and veteran trees. Cetaceans, seals, marine turtles, fish (for example, seahorses, sharks, skates)

A map showing the location of statutory protected sites is given in Figure A2.1.

We also considered potential future impact on the replacement SSSI at Aldhust Farm and some non-statutory protected sites local to Sizewell nuclear site. We consider the assessment of the SSSI at Sizewell Marshes to be representative of any impacts at the replacement SSSI at Aldhurst Farm. The non-statutory protected local sites we considered are listed below.

Non-statutory protected sites local to Sizewell nuclear site

Southern Minsmere Levels CWS

Coniferous woodland. Breeding birds, roosting and foraging bats, invertebrates (including the white admiral butterfly and Norfolk hawker dragonfly) and reptiles.

Sizewell Levels and associated areas CWS

Woodland, plantation, wet meadow, osier beds and scrub. High numbers of waterfowl

Leiston Common CWS

Lowland heath. Breeding birds and a diverse assemblage of reptiles and invertebrates

Suffolk Shingle Beaches CWS

Coastal sand and shingle habitats. Invertebrates, reptiles and foraging black redstarts.

Dower House CWS

Cliff-top unimproved dry acid/dry maritime grassland. Heath dog violet.

Aldringham to Aldeburgh Disused Railway CWS

Track and embankments. Species diverse flora

Sizewell Rigs CWS

Breeding colony of kittiwake

The sites and the wildlife inhabiting them were reviewed using the resources available from Natural England (Natural England, 2020), the Suffolk Wildlife Trust (SWT) (Suffolk Wildlife Trust, 2020) and the Suffolk Biodiversity Information Service (SBIS) (Suffolk Biodiversity Information Service, 2018). The specific locations selected for the assessment are given in Tables A2.1, A2.2 and A2.3. The locations were selected due to their proximity to the proposed SZC nuclear power station and their high level of biodiversity. The wildlife inhabiting these sites is very diverse and must be represented by a limited number of ROs. The ROs, as defined in the ERICA tool (Brown et al, 2016), are listed in Tables A2.4 to A2.6 which include examples of the specific organisms they are intended to represent. Table A2.4 also includes additional organisms that are not well represented by the Ros, the data used to define these additional reference organisms is shown in Tables 2.7 and 2.8.

Useful input to the review of wildlife sites was obtained from the numerous studies that have been conducted to establish the environmental baseline conditions around the Sizewell site. These include ornithological as well as terrestrial and marine ecological studies. The main findings of these studies are summarised in the Sizewell C EIA Scoping Report (EDF Energy, 2014). The surveyed habitats include important areas of woodland, marshland and coastal sand and shingle. The wildlife identified include endangered invertebrate species and important populations of reptiles (adder, grass snake, slow worm and common lizard), mammals (bats, otters, badgers, water voles) and birds (breeding, wintering and seabirds). In addition, mapping of the seabed and surveys of intertidal and subtidal regions have taken place and requirements for further studies have been identified. The report also lists key designated sites and provides a brief description of their habitats.

Table A2.1 Location of specific receptor points used in wildlife dose assessments - discharges to atmosphere– relative to south stack

Assessment site	Location	Grid reference	Distance (m)	Angle (°) *
Sizewell Marshes	Point nearest to SZC	TM47096420	290	335
	Point in middle of Sizewell Marshes	TM46566383	660	260

* Clockwise from north

Table A2.2 Location of specific receptor points used in wildlife dose assessments - discharges to atmosphere - relative to north stack

Assessment site	Location	Grid reference	Distance (m)	Angle (°) *
Minsmere #	Point nearest to SZC	TM47406450	380	30
	Point in middle of Scrape region	TM47506672	2570	6

* Clockwise from north

This is the southern end of the Minsmere-Walberswick Heaths and Marshes SSSI which extends from just north of the Sizewell site to Southwold.

Table A2.3 Location of specific receptor points used in wildlife dose assessments – liquid discharges

Assessment site	Location
Outer Thames Estuary	Local compartment of DORIS model

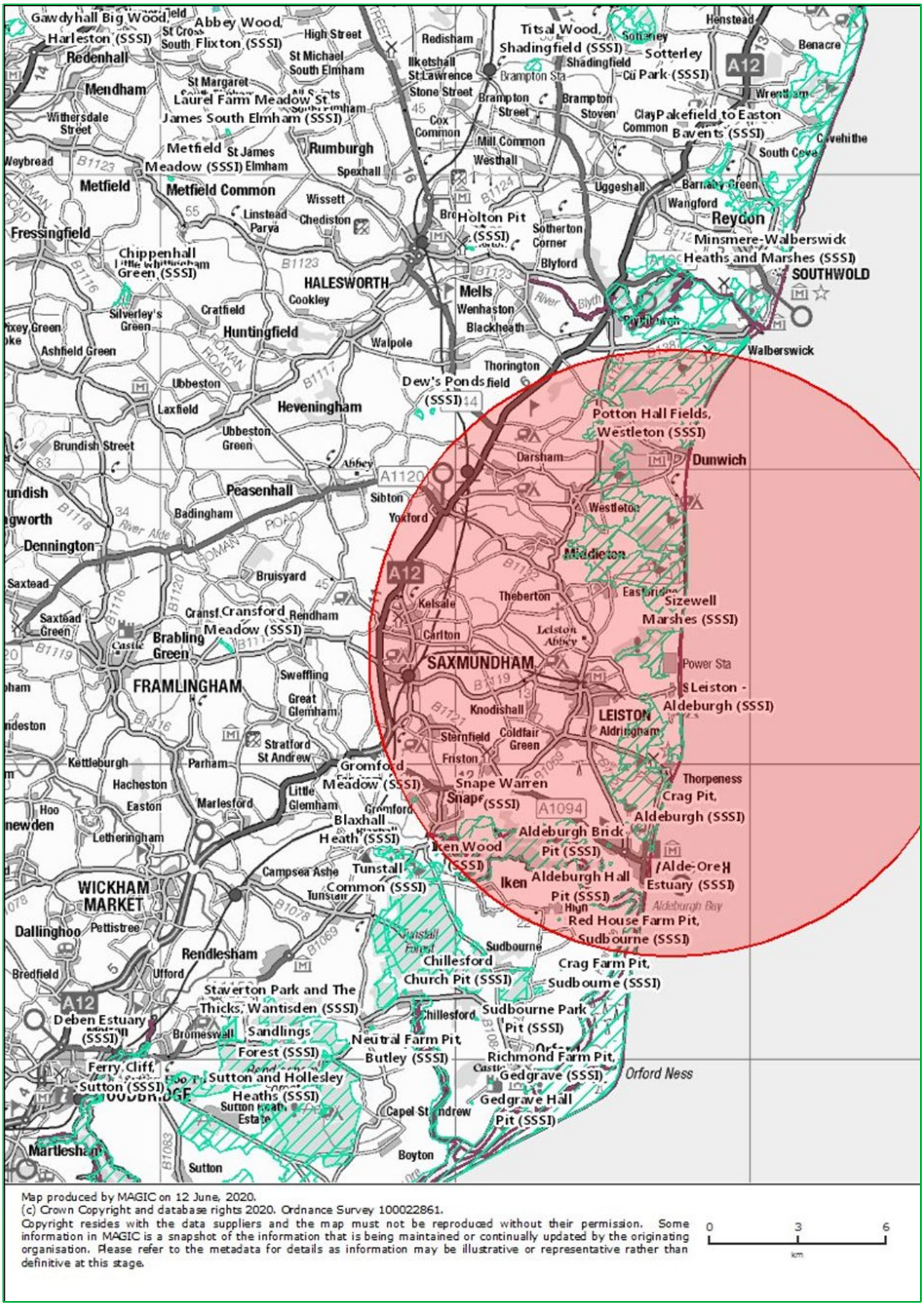

Figure A2.1 Map showing location of statutory protected sites within 10 km (red circle) or Sizewell nuclear site (note: Minsmere-Walberswick Heaths and Marshes SSSI extends from just north of the Sizewell site to Southwold)

Reference organisms

Tables A2.6 to A2.8 list the default ROs, as defined in the ERICA tool (Brown et al, 2016), and examples of the specific organisms living in habitats near to the Sizewell site that they are intended to represent. Table A2.6 also includes two additional organisms that were set up in ERICA because they are not well represented by the default ROs. These are discussed further in the next section.

Table A2.4 Terrestrial reference organisms

Reference organism	ERICA default	Examples of specific wildlife present in the region
Amphibian	Yes	Great crested newt, natterjack toad (only found within Sizewell nuclear site)
Annelid	Yes	-
Arthropod - detritivorous	Yes	Stag beetle
Bird	Yes	Lapwing, nightjar, woodlark, short-eared owl, wheatear and marsh harrier
Flying insect	Yes	White admiral, Norfolk hawker
Grasses & Herbs	Yes	Plants of heathland, grazing marsh and acid grassland
Lichen & Bryophytes	Yes	Plants generally of woodland areas loving damp and shade, including mosses and liverworts
Mammal - large	Yes	Deer (red, roe, fallow, muntjac)
Mammal - small-burrowing	Yes	Field vole, harvest mouse, dormouse
Mollusc - gastropod	Yes	-
Reptile	Yes	Adder, grass snake, slow worm and common lizard
Shrub	Yes	Heather
Tree	Yes	Coniferous and deciduous
Badger*	No	Large burrowing mammal (badger, fox)
Bat	No	Barbastelle, Natterer's, soprano pipistrelles and brown long-eared bats

* Badger is modelled in ERICA as both an above and a below ground dweller to better represent its mass.

Table A2.5 Freshwater reference organisms

Reference organism	ERICA default	Examples of specific wildlife
Amphibian	Yes	Great crested newt, natterjack toad (only found within Sizewell nuclear site)
Benthic fish	Yes	Eels
Bird	Yes	Bittern and water rail
Crustacean	Yes	-
Insect larvae	Yes	-
Mammal	Yes	Otter, water vole
Mollusc - bivalve	Yes	-
Mollusc - gastropod	Yes	Ramshorn snail
Pelagic fish	Yes	Trout, perch
Phytoplankton	Yes	-
Reptile	Yes	Grass snake
Vascular plant	Yes	-
Zooplankton	Yes	-

Table A2.6 Marine reference organisms

Reference organism	ERICA default	Examples of specific wildlife
Benthic fish	Yes	Dover and lemon sole, skates and rays
Bird	Yes	wigeon, shelduck, redshank and dunlin, common tern, little tern and red-throated diver
Crustacean	Yes	Edible crab
Macroalgae	Yes	-
Mammal	Yes	Harbour porpoise
Mollusc - bivalve	Yes	Mussels, cockles
Pelagic fish	Yes	Mullet, bass
Phytoplankton	Yes	-
Polychaete worm	Yes	-
Reptile	Yes	Leatherback turtles
Sea anemone & True coral	Yes	-
Vascular plants	Yes	-
Zooplankton	Yes	-

Definition of badger and bat categories

In addition to the default reference organisms included in the ERICA tool, two terrestrial animal groups were created to represent large burrowing mammals ('badger') and bats. These groups were set up in the ERICA tool using the 'Add Organism' feature. Some of the limitations that ERICA places on the choice of parameter values impacted on these groups. For bats, which used the specimen category of 'Bird or flying insect', the minimum value for mass is 35 g and for a mammal living in the soil the maximum mass is 6.6 kg. A mass of 35 g for a British bat is quite high, the common pipistrelle has a mass of about 5 g while the noctule is about 28 g. A mass of 6.6 kg is low for an adult badger which is generally about 12 kg. However, for a mammal living on the soil, where a badger spends some of its time, a greater mass can be selected. Therefore, for the 'badger' category two separate groups were set up, 'BadgerInGrnd' for in-soil occupancy and 'BadgerOnGrnd' for on-soil occupancy. The latter could be represented by a more realistic body mass. The dose rates per unit concentration from the two badger groups were combined, taking account of relative occupancies, to get mean values for this group. Organism dimensions were selected to be representative of each group while ensuring a reasonable body density was maintained. The data used to define the bat and the badger groups are presented in Tables A2.9 - A2.11.

Table A2.7 Parameter values used to define the badger and the bat groups in ERICA - organism name: BadgerInGrnd

Parameter	Value
Wildlife group	Mammal
Specimen	Ground-living animal
On-soil occupancy	0.0
In-soil occupancy	1.0
In-air	-
Maximum height over ground (m)	-
Radiation source	Infinite volume isotropic source uniformly distributed to 10 cm depth
Organism mass (kg)	6.6 (the maximum allowed in ERICA for in-soil mammal)
Organism dimensions (m)	
Height	0.2
Width	0.2
Length	0.33

Table A2.8 Parameter values used to define the badger and the bat groups in ERICA - organism name: BadgerOnGrnd

Parameter	Value
Wildlife group	Mammal
Specimen	Ground-living animal
On-soil occupancy	1.0
In-soil occupancy	0.0
In-air	-
Maximum height over ground (m)	-
Radiation source	Infinite volume isotropic source uniformly distributed to 10 cm depth
Organism mass (kg)	12
Organism dimensions (m)	
Height	0.2
Width	0.2
Length	0.6

Table A2.9 Parameter values used to define the badger and the bat groups in ERICA - organism name: Bat

Parameter	Value
Wildlife group	Mammal
Specimen	Bird or flying insect
On-soil occupancy	0.5
In-soil occupancy	0.0
In-air	0.5
Maximum height over ground (m)	5.0
Radiation source	Infinite volume isotropic source uniformly distributed to 10 cm depth
Organism mass (kg)	0.035 (minimum allowed in ERICA for this organism)
Organism dimensions (m)	
Height	0.06
Width	0.035
Length	0.035

Environmental activity concentrations calculated using PC-CREAM 08

PC-CREAM 08 was used to calculate environmental activity concentrations following 60 years of operation of SZC for input to the wildlife dose assessment.

For discharges to atmosphere the PLUME and GRANIS models in PC-CREAM 08 were used to calculate activity concentrations in air and soil per unit release rate at the required locations. For Minsmere and Sizewell Marshes, locations were selected in the middle of each site and at the point closest to SZC (Tables A2.1, A2.2 and A2.3), this was done to scope the range of possible dose rates. Mean activity concentrations in dry soil were calculated for a depth of 0 to 15 cm so they could be used with data from ERICA. The ERICA tool and 'Ar-Kr-Xe dose calculator' were used to derive dose rates per unit activity concentration for each RO and the additional groups badger and bat. These results were then scaled by the environmental activity concentrations calculated using PC-CREAM 08 and the annual discharge rate of each radionuclide to obtain dose rates for the proposed discharges. Environmental activity concentrations are presented in Tables A2.10 and A2.11.

Although no direct discharges to freshwater systems are proposed for SZC, radionuclides could enter the freshwater environment as a result of atmospheric deposition onto water bodies and their catchments. This exposure pathway is not modelled in PC-CREAM 08 and therefore a screening assessment was carried out to consider exposure of freshwater wildlife to atmospheric deposition. The approach adopted is based on that described in IAEA report SRS 19 (IAEA, 2001) which uses a deposition rate and the area of the water body to estimate the rate at which activity enters the water body. Deposition onto the catchment is included by assuming it has an area 100 times bigger than that of the water body and that 2% of the deposited activity is transferred to the water body. The concentration in the water body after 60 years of operation of the site is then calculated. It is worth noting that in this screening approach the surface area of the lake does not impact on dose because although deposition increases in proportion to the area of the lake and catchment, activity concentrations in water reduce in the same proportion. However, the lake depth does impact on predicted activity concentrations because the total deposit is diluted over a greater volume of water.

Deposition of H-3 and C-14 is not modelled in PC-CREAM 08 and therefore a different approach, based on a specific activity model, is used to determine activity concentrations of these radionuclides in freshwater. The assumption is made that the specific activity of H-3 and C-14 in the dispersing plume at the location of interest are the same as in the water body. The specific activity for H-3 is expressed in terms of Bq (H-3) per kg (H_20) per Bq m^{-3} (H-3) and for C-14 in terms of Bq (C-14) per kg (C-12) per Bq m^{-3} (C-14) (Smith and Simmonds, 2009). This approach requires that an assumption is made regarding the concentration of C-12 in the freshwater ecosystem. A value of 0.02 kg m^{-3} of C-12 in water was taken from (NCRP, 1996).

The screening methods for the calculation of activity concentrations in freshwater involve considerable uncertainty, in part because they are based on the deposition rate at a single location rather than over the water body and its catchment area as a whole. The methods are quite cautious and are likely to provide an upper estimate of the activity concentrations in freshwater. The data used in the assessment are summarised in Table A2.13 and activity concentrations presented in Table A2.14.

For liquid discharges to sea, activity concentrations in the marine environment (Table A2.15) were calculated using the DORIS model and combined with dose rates per unit activity concentration from ERICA and discharge rates to determine doses to each RO. All marine wildlife was assumed to be located in the local Sizewell compartment of the DORIS model which represents the Outer Thames Estuary NATURA 2000 SPA.

Table A2.10 Activity concentration in air (Bq m^{-3}) used in terrestrial wildlife assessment for SZC proposed discharges

Radionuclide	Minsmere nearest point	Minsmere Scrape	Sizewell marshes nearest point	Sizewell marshes mid-point
Ar-41	$9.5\ 10^{-2}$	$4.9\ 10^{-3}$	$4.7\ 10^{-2}$	$2.0\ 10^{-2}$
C-14	$1.0\ 10^{-1}$	$5.6\ 10^{-3}$	$5.0\ 10^{-2}$	$2.2\ 10^{-2}$
H-3	$4.4\ 10^{-1}$	$2.4\ 10^{-2}$	$2.1\ 10^{-1}$	$9.4\ 10^{-2}$
Kr-85	$4.6\ 10^{-1}$	$2.5\ 10^{-2}$	$2.2\ 10^{-1}$	$9.8\ 10^{-2}$
Xe-131m	$9.9\ 10^{-3}$	$5.4\ 10^{-4}$	$4.8\ 10^{-3}$	$2.1\ 10^{-3}$
Xe-133	$2.1\ 10^{0}$	$1.1\ 10^{-1}$	$1.0\ 10^{0}$	$4.4\ 10^{-1}$
Xe-135	$6.5\ 10^{-1}$	$3.5\ 10^{-2}$	$3.2\ 10^{-1}$	$1.4\ 10^{-1}$

Table A2.11 Mean activity concentration in soil (0 to 15 cm) (Bq kg^{-1} dry weight) used in terrestrial wildlife assessment for SZC proposed discharges

Radionuclide	Minsmere nearest point	Minsmere Scrape	Sizewell marshes nearest point	Sizewell marshes mid-point
Co-58	$1.8\ 10^{-4}$	$1.4\ 10^{-5}$	$9.2\ 10^{-5}$	$3.2\ 10^{-5}$
Co-60	$5.4\ 10^{-3}$	$4.2\ 10^{-4}$	$2.8\ 10^{-3}$	$9.7\ 10^{-4}$
Cs-134	$1.7\ 10^{-3}$	$1.3\ 10^{-4}$	$8.9\ 10^{-4}$	$3.1\ 10^{-4}$
Cs-137	$1.3\ 10^{-2}$	$9.8\ 10^{-4}$	$6.5\ 10^{-3}$	$2.3\ 10^{-3}$
I-131	$1.7\ 10^{-3}$	$8.9\ 10^{-5}$	$8.2\ 10^{-4}$	$3.4\ 10^{-4}$
I-133	$2.1\ 10^{-4}$	$1.1\ 10^{-5}$	$1.1\ 10^{-4}$	$4.4\ 10^{-5}$

Table A2.12 Deposition rate onto freshwater body (Bq m^{-2} s^{-1}) used in freshwater wildlife assessment for SZC proposed discharges

Radionuclide	Minsmere Scrape	Sizewell marshes mid-point
C-14 *	-	-
Co-58	$2.9\ 10^{-10}$	$6.8\ 10^{-10}$
Co-60	$3.5\ 10^{-10}$	$8.0\ 10^{-10}$
Cs-134	$2.7\ 10^{-10}$	$6.2\ 10^{-10}$
Cs-137	$2.4\ 10^{-10}$	$5.6\ 10^{-10}$
H-3 *	-	-
I-131	$1.7\ 10^{-8}$	$6.4\ 10^{-8}$
I-133	$2.0\ 10^{-8}$	$7.6\ 10^{-8}$

* Use specific activity approach as described in this appendix

Table A2.13 Data for modelling deposition onto freshwater habitats

Parameter	Value
Dimensions of water body Minsmere near to SZC	Area (m^2) 1.00 10^6 Depth (m) 1
Dimensions of water body Minsmere Scrape (EandW)	Area (m^2) 1.74 10^5 Depth (m) 1
Dimensions of water body Sizewell marshes near to SZC	Area (m^2) 1.05 10^6 Depth (m) 1
Dimensions of water body Sizewell marshes mid	Area (m^2) 1.05 10^6 Depth (m) 1
Multiplying factor for area of catchment	100
Fraction of activity falling on catchment transferred to water body (%)	2
Build-up time (y)	60
Specific activity for H-3 (Bq (H-3) per kg (H_2O) per Bq m^{-3} (H-3))	1.25 10^2
Mass of H_2O in freshwater (kg m^{-3})	1000
Specific activity for C-14 (Bq (C-14) per kg (C-12) per Bq m^{-3} (C-14))	6.67 10^3
Mass of C-12 in freshwater (kg m^{-3})	0.02

Table A2.14 Activity concentration (Bq l^{-1}) in freshwater bodies from atmospheric deposition for SZC proposed discharges

Radionuclide	Minsmere Scrape	Sizewell marshes mid-point
C-14	$7.4\ 10^{-4}$	$2.9\ 10^{-3}$
Co-58	$7.8\ 10^{-6}$	$1.8\ 10^{-5}$
Co-60	$2.5\ 10^{-4}$	$5.7\ 10^{-4}$
Cs-134	$7.6\ 10^{-5}$	$1.7\ 10^{-4}$
Cs-137	$7.4\ 10^{-4}$	$1.7\ 10^{-3}$
H-3	$3.0\ 10^{0}$	$1.2\ 10^{1}$
I-131	$5.0\ 10^{-5}$	$1.9\ 10^{-4}$
I-133	$6.4\ 10^{-6}$	$2.5\ 10^{-5}$

Table A2.15 Activity concentration in seawater (Bq l^{-1}) used in marine wildlife assessment for SZC proposed discharges

Radionuclide	Outer Thames Estuary
Ag-110m	$6.6\ 10^{-5}$
C-14	$1.3\ 10^{-2}$
Co-58	$1.6\ 10^{-5}$
Co-60	$3.4\ 10^{-5}$
Cr-51	$1.1\ 10^{-6}$
Cs-134	$6.4\ 10^{-5}$
Cs-137	$1.2\ 10^{-4}$
H-3	$1.4\ 10^{1}$
I-131	$1.3\ 10^{-6}$
Mn-54	$2.6\ 10^{-6}$
Ni-63	$2.5\ 10^{-5}$
Sb-124	$4.1\ 10^{-5}$
Sb-125	$1.1\ 10^{-4}$
Te-123m	$2.7\ 10^{-5}$

Dose rates to reference organisms

Minsmere-Walberswick Heaths

In this region, both terrestrial and freshwater biota are potentially affected by SZC discharges. Dose rates to terrestrial biota were calculated for two locations within this region, the point nearest to the proposed SZC nuclear plant and a point in the middle of the East and West Scrape region. This was done to scope the range of possible dose rates. Dose rates to freshwater biota were only calculated for a point in the middle of the Scrape region because these water bodies receive runoff from a large area and it would not be representative to calculate dose rates based on activity concentrations at the closest point to SZC.

Table A2.16 Dose rates to terrestrial wildlife due to discharges to atmosphere from SZC at proposed limits

Reference organism	Location nearest to SZC Dose rate (μGy h^{-1})	East and west Scrape Dose rate (μGy h^{-1})
Amphibian	$4.5\ 10^{-3}$	$2.4\ 10^{-4}$
Annelid	$1.8\ 10^{-3}$	$9.9\ 10^{-5}$
Arthropod – detritivorous	$1.8\ 10^{-3}$	$9.9\ 10^{-5}$
Bird	$4.6\ 10^{-3}$	$2.5\ 10^{-4}$
Flying insect	$1.8\ 10^{-3}$	$9.6\ 10^{-5}$
Grasses and herbs	$3.1\ 10^{-3}$	$1.7\ 10^{-4}$
Lichen and bryophytes	$3.2\ 10^{-3}$	$1.7\ 10^{-4}$
Mammal – large	$4.6\ 10^{-3}$	$2.5\ 10^{-4}$
Mammal – small-burrowing	$4.6\ 10^{-3}$	$2.5\ 10^{-4}$
Mollusc – gastropod	$1.8\ 10^{-3}$	$9.8\ 10^{-5}$
Reptile	$4.6\ 10^{-3}$	$2.5\ 10^{-4}$
Shrub	$3.1\ 10^{-3}$	$1.7\ 10^{-4}$
Tree	$4.5\ 10^{-3}$	$2.4\ 10^{-4}$
Badger	$4.6\ 10^{-3}$	$2.5\ 10^{-4}$
Bat	$4.6\ 10^{-3}$	$2.5\ 10^{-4}$

Table A2.17 Dose rates to freshwater wildlife due to discharges to atmosphere from SZC at proposed limits

Reference organism	East and West Scrape Dose rate (µGy h^{-1})
Amphibian	$4.3\ 10^{-3}$
Benthic fish	$4.2\ 10^{-2}$
Bird	$4.4\ 10^{-3}$
Crustacean	$4.9\ 10^{-2}$
Insect larvae	$9.4\ 10^{-2}$
Mammal	$4.4\ 10^{-3}$
Mollusc – bivalve	$4.5\ 10^{-2}$
Mollusc – gastropod	$4.6\ 10^{-2}$
Pelagic fish	$4.5\ 10^{-3}$
Phytoplankton	$1.2\ 10^{-4}$
Reptile	$4.2\ 10^{-2}$
Vascular plant	$4.5\ 10^{-2}$
Zooplankton	$3.7\ 10^{-3}$

Sizewell Marshes

In this region, both terrestrial and freshwater biota are potentially affected by SZC discharges. Dose rates to terrestrial biota were calculated for two locations within this region, the point nearest to the proposed SZC nuclear plant and the mid-point of this region. This was done to scope the range of possible dose rates. As was the case for Minsmere, dose rates to freshwater biota were only calculated for a point in the middle of this region.

Table A2.18 Dose rates to terrestrial wildlife due to discharges to atmosphere from SZC at proposed limits

Reference organism	Sizewell marshes location nearest to SZC Dose rate (µGy h^{-1})	Sizewell marshes mid-point of region Dose rate (µGy h^{-1})
Amphibian	$2.2\ 10^{-3}$	$9.5\ 10^{-4}$
Annelid	$8.8\ 10^{-4}$	$3.9\ 10^{-4}$
Arthropod – detritivorous	$8.8\ 10^{-4}$	$3.9\ 10^{-4}$
Bird	$2.2\ 10^{-3}$	$9.8\ 10^{-4}$
Flying insect	$8.6\ 10^{-4}$	$3.8\ 10^{-4}$
Grasses and herbs	$1.5\ 10^{-3}$	$6.7\ 10^{-4}$
Lichen and bryophytes	$1.6\ 10^{-3}$	$6.8\ 10^{-4}$

Reference organism	Sizewell marshes location nearest to SZC Dose rate (µGy h^{-1})	Sizewell marshes mid-point of region Dose rate (µGy h^{-1})
Mammal – large	$2.3\ 10^{-3}$	$9.9\ 10^{-4}$
Mammal – small-burrowing	$2.3\ 10^{-3}$	$9.9\ 10^{-4}$
Mollusc – gastropod	$8.8\ 10^{-4}$	$3.8\ 10^{-4}$
Reptile	$2.2\ 10^{-3}$	$9.8\ 10^{-4}$
Shrub	$1.5\ 10^{-3}$	$6.7\ 10^{-4}$
Tree	$2.2\ 10^{-3}$	$9.6\ 10^{-4}$
Badger	$2.2\ 10^{-3}$	$9.8\ 10^{-4}$
Bat	$2.2\ 10^{-3}$	$9.7\ 10^{-4}$

Table A2.19 Dose rates to freshwater wildlife due to discharges to atmosphere from SZC at proposed limits

Reference organism	Sizewell marshes mid-point of region Dose rate (µGy h^{-1})
Amphibian	$1.6\ 10^{-2}$
Benthic fish	$1.1\ 10^{-1}$
Bird	$1.7\ 10^{-2}$
Crustacean	$1.2\ 10^{-1}$
Insect larvae	$2.3\ 10^{-1}$
Mammal	$1.7\ 10^{-2}$
Mollusc – bivalve	$1.1\ 10^{-1}$
Mollusc – gastropod	$1.1\ 10^{-1}$
Pelagic fish	$1.7\ 10^{-2}$
Phytoplankton	$4.6\ 10^{-4}$
Reptile	$1.0\ 10^{-1}$
Vascular plant	$1.1\ 10^{-1}$
Zooplankton	$1.5\ 10^{-2}$

Outer Thames Estuary

The Outer Thames Estuary is a NATURA 2000 SPA surrounding the Sizewell site. The local compartment of the DORIS model was used to represent the region of the Outer Thames Estuary closest to the Sizewell discharge pipe. The DORIS model was set up in the same way as for the human dose assessment (Table A3.4), with SZC discharges being made into the local compartment of the DORIS model. Any activity entering this compartment was assumed to be instantly diluted throughout the compartment.

Consequently, dose rates calculated to marine biota are representative of the mean activity concentrations expected to be found in this region. This is a reasonable approach given that the aim of the assessment is to ensure the integrity of the site as a whole and the wildlife populations living there. Individual biota living immediately in the vicinity of the outfall from the site are likely receive higher dose rates than the regional means.

Table A2.20 Dose rates to marine wildlife due to liquid discharges from SZC at proposed limits

Reference organism	Local compartment Dose rate (µGy h^{-1})
Benthic fish	2.7 10^{-2}
Bird	1.4 10^{-3}
Crustacean	2.7 10^{-2}
Macroalgae	2.9 10^{-2}
Mammal	2.6 10^{-3}
Mollusc – bivalve	2.8 10^{-2}
Pelagic fish	9.7 10^{-4}
Phytoplankton	3.8 10^{-4}
Polychaete worm	6.0 10^{-2}
Reptile	2.6 10^{-3}
Sea anemone and true coral	2.9 10^{-2}
Vascular plants	2.8 10^{-2}
Zooplankton	3.8 10^{-3}

References

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Appendix 3 Additional data for permitted discharges assessment

Introduction

This appendix provides additional information on the methods used to calculate doses to the local population arising as a consequence of permitted discharges from the proposed Sizewell C nuclear power station and the existing power stations (Sizewell A and B) on the Sizewell nuclear site. Input data for the models are presented, the application of meteorological data is discussed, environmental activity concentrations calculated using PC-CREAM 08 are given and doses to the more exposed candidates for representative person are presented for SZC. Details of the methodology used for calculating ingestion doses from foods not included in PC-CREAM 08 are also provided.

Atmospheric dispersion modelling

The models used to calculate doses from permitted discharges to atmosphere from the Sizewell site were PLUME, GRANIS, FARMLAND and RESUS as implemented in PC-CREAM 08 v1.5.1.92/2.0.0 (Smith and Simmonds, 2009). Input data used in these models are presented in Tables A3.1 and A3.2. Discharges to atmosphere are mostly gaseous radionuclides with a small quantity of particulates carrying radionuclides.

Dispersion and deposition of radionuclides released to the atmosphere were modelled using PLUME. A site-specific scenario was set up that took account of the source terms, stack heights and locations, meteorological conditions and receptor points. For other model parameters, such as deposition velocities, washout coefficients and roughness length, PC-CREAM 08 defaults were used. The outputs from PLUME are activity concentrations in air, deposition rates and cloud gamma dose rates. In terms of progeny considered, these outputs included the ingrowth of the first member of the decay chain. This enables activity concentrations and doses from progeny with short half-lives to be modelled explicitly which can be important given the short time scales of interest when considering atmospheric dispersion.

External exposure to gamma emitting radionuclides deposited on the ground was modelled using GRANIS. The undisturbed, wet soil model in GRANIS is a generic model intended to represent a variety of UK soil types. Inland of SZC there are three dominant soil types: freely draining slightly acid sandy soils, fen peat soils, and loamy and clayey soils of coastal flats with naturally high groundwater (Cranfield Soil and Agrifood Institute, 2020). Although the GRANIS model could be altered to better represent local soil types the dose assessment did not suggest that this was necessary. In the undisturbed soil model the ground is represented by five soil layers (0-1 cm, 1 to 5 cm, 5 to 15 cm, 15 - 30 cm and 30 - 100 cm) of infinite lateral extent and it is assumed that deposition over the surface is uniform. Migration over time of radionuclides through the soil layers is modelled. The effective dose in a year is calculated 1 m above the ground assuming a continuous and constant deposition rate for the discharge period, i.e. 60 years for this study. The results from GRANIS, which are in terms of dose per unit deposition rate for each radionuclide, are scaled by the predicted deposition rates from PLUME. GRANIS models the whole radioactive decay chain for each radionuclide that deposits onto the ground.

Radioactive material released to the atmosphere can be deposited onto agricultural land and taken up by plants and animals that form part of the foodchain. The ingestion of these foods by individuals living near to the site can be an important exposure pathway. In PC-CREAM 08 the uptake and accumulation of radionuclides in plants and animals is modelled using FARMLAND. FARMLAND calculates activity concentrations per unit deposition rate in a variety of foods that are key components of a typical UK diet, such as cow milk, cow meat, cow liver, sheep meat, sheep liver, green vegetables, fruit, root vegetables and grain. In this study, locally produced cow milk was not included in the local diet (Appendices 1 and 3) and grain was only considered in the calculation of collective doses and as animal feed and not as a foodstuff for humans. This is because grain for human consumption requires processing, generally done on a large commercial scale using grain collected from across the country. The FARMLAND model could be modified to use soil to plant concentration ratios for local soil types but this additional work was not justified given the level of dose calculated and the effort required to compile the necessary datasets. The activity concentrations in food are scaled by the predicted deposition rates from PLUME. FARMLAND models up to two significant radioactive progeny in the decay chain.

Other foods that were considered in the assessment but are not included in FARMLAND are pork, poultry, eggs and some wild foods, i.e. wild game, mushrooms, nuts, berries and honey. Activity concentrations in pork, poultry and eggs were calculated on the basis that pigs and chickens eat grain. Activity concentrations in wild foods were calculated using factors that directly relate the concentration in the wild food to environmental concentrations. Further details are provided below.

The RESUS model was used to calculate activity concentrations in air arising from wind driven resuspension processes. In general, it is only important as an exposure pathway if actinides form a significant component of the source term. It is intended to represent long term processes that contribute to the ambient activity concentrations in air and not the high levels of resuspension that can result from acute mechanical disturbances such as driving vehicles. RESUS models up to two significant radioactive progeny in the decay chain.

Table A3.1 Input data for atmospheric dispersion and deposition modelling using PLUME

Parameter	Value
Physical stack height (m)	Sizewell C (2 stacks) = 70
Dominant building height (m)	Sizewell C = 60
Effective stack height (m)	Sizewell C (2 stacks) = 20 Sizewell B (1 stack) = 19 Sizewell A (1 stack) = 0
Deposition velocity (m/s)	H-3 = deposition not modelled* C-14 = deposition not modelled* Iodine (elemental) = 1.0 10^{-2} noble gases = 0 'other beta emitting radionuclides' = 1.0 10^{-3}
Washout coefficient (1/s)	H-3 = deposition not modelled C-14 = deposition not modelled Iodine (elemental) = 1.0 10^{-4} noble gases = 0 'other beta emitting radionuclides' = 1.0 10^{-4}

Parameter	Value
Roughness length (m)	Agricultural areas = 0.3
Meteorological scheme	Hosker-Smith
Meteorological data	See Appendix 3

* Uptake into plants and animals is estimated using specific activity models. Theses are most appropriate for tritium in the form of tritiated water vapour and C-14 in the form of CO_2. However, C-14 could be released in particulate form and therefore the inhalation dose coefficients for C-14 are based on 1 µm particles with absorption type M as these are more cautious than for CO_2.

Table A3.2 Input data for other models

Model	Parameter	Value
GRANIS	Soil model	Undisturbed soil
GRANIS	Soil type	Generic wet soil
GRANIS	Output times (y)	60
FARMLAND	Models	All foodstuffs
FARMLAND	Plant dependent	Defaults
FARMLAND	Animal dependent	Defaults
FARMLAND	Plant concentration ratios	Defaults
FARMLAND	Animal equilibrium transfer factors	Defaults
FARMLAND	Other element dependent	Defaults
FARMLAND	Output times (y)	60
RESUS	Not applicable	Not applicable
RESUS	Output times (y)	60

Meteorological data

Hourly sequential meteorological data were obtained from the Met Office numerical weather prediction (NWP) model for the Sizewell site covering a five year period from 2015 to 2019. The data were extracted in a format that could be processed by PC-CREAM 08 into the statistical data it requires to model the dispersion of radioactivity in the atmosphere. An example of the extracted data is given in Figure A3.1 and includes wind speed, wind direction, boundary layer height, precipitation rate and Pasquill stability category. The processing tool included in PC-CREAM 08 reads the hourly sequential meteorological data and calculates the frequency with which the wind blows into each 30 sector around the Sizewell site and the frequency with which different stability categories occur. These frequencies are combined to produce the meteorological input file used by PLUME. The processed data for Sizewell is shown in Figure A3.2 and the corresponding wind rose in Figure 3. The processing tool also calculates the mean wind speed and boundary layer height for each stability category (Table A3.3). These data are also used in PLUME by entering them into the 'Met sampling scheme' window of the model interface.

SS_Met_Mk2_C1_X1_Y1.txt - Notepad

```
NAME III (version 7.2) PHE0
Run name:                   Sizewell_SS_Extract
Run time:                   16/03/2020 18:02:13.035 UTC
Met data:                   NWP Flow.1pt5km_NWP_Flow
Start of release:           infinity
End of release:             -infinity
Source strength:            No Sources
Release location:           No Sources
Release height:             No Sources
Run duration:               30day 23hr 0min
X grid origin:                 1.619720
Y grid origin:                 52.21500
X grid size:                          1
Y grid size:                          1
X grid resolution:             200.0000
Y grid resolution:             200.0000
Number of preliminary cols:           1
Number of field cols:                 5

Fields:
                         ,                         ,                         ,                         ,                         ,                         ,
                         ,                   Req 1,                    Req 2,                    Req 3,                    Req 4,                    Req 5,
                         ,             Wind speed,  Wind direction (degrees),      Boundary layer depth,Precipitation rate (mm/hr),       Pasquill Stability,
                         ,                         ,                         ,                         ,                         ,                         ,
                         ,                  m / s,                      deg,                        m,                  mm / hr,                         ,
                         ,                         ,                         ,                         ,                         ,                         ,
                         ,    No ensemble averaging,    No ensemble averaging,    No ensemble averaging,    No ensemble averaging,    No ensemble averaging,
                         ,        No time averaging,        No time averaging,        No time averaging,        No time averaging,        No time averaging,
                         ,  No horizontal averaging,  No horizontal averaging,  No horizontal averaging,  No horizontal averaging,  No horizontal averaging,
                         ,    No vertical averaging,    No vertical averaging,    No vertical averaging,    No vertical averaging,    No vertical averaging,
                         ,                         ,                         ,                         ,                         ,                         ,
                         ,                         ,                         ,                         ,                         ,                         ,
                         ,                         ,                         ,                         ,                         ,                         ,
                         ,  No horizontal averaging,  No horizontal averaging,  No horizontal averaging,  No horizontal averaging,  No horizontal averaging,
                         ,    X = 1.619720 Lat-Long,    X = 1.619720 Lat-Long,    X = 1.619720 Lat-Long,    X = 1.619720 Lat-Long,    X = 1.619720 Lat-Long,
                         ,    Y = 52.21500 Lat-Long,    Y = 52.21500 Lat-Long,    Y = 52.21500 Lat-Long,    Y = 52.21500 Lat-Long,    Y = 52.21500 Lat-Long,
                         ,      Z = 10.00000 m agl,      Z = 10.00000 m agl,      Z = 10.00000 m agl,      Z = 10.00000 m agl,      Z = 10.00000 m agl,
                         ,                         ,                         ,                         ,                         ,                         ,
                        T,                         ,                         ,                         ,                         ,                         ,
    01/01/2015 00:00 UTC,                 6.855157,                 211.8695,                 233.2119,           0.0000000E+00,                 3.738647,
    01/01/2015 01:00 UTC,                 6.784733,                 216.8112,                 233.2119,           0.0000000E+00,                 3.742358,
    01/01/2015 02:00 UTC,                 6.556660,                 212.6944,                 233.2119,           0.0000000E+00,                 3.916540,
```

Figure A3.1 Example of data extracted from Met Office NWP model

PCCREAM SZC met file.TXT - Notepad

```
SS_Met_MkAll_C1_X1_Y1: NWP create 13:39:42
1
12, 15
A,  B,  C,  D,  E,  F,  C Rain,  D Rain
0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
0.000E+00  4.564E-05  4.564E-05  2.282E-05  4.564E-05  2.282E-05  2.282E-04  2.282E-03  2.122E-03  2.054E-03  7.986E-04  2.282E-05
3.560E-03  1.050E-02  1.114E-02  1.463E-02  6.412E-03  3.446E-03  1.075E-02  1.349E-02  8.352E-03  7.827E-03  1.200E-02  9.903E-03
8.724E-02  9.159E-02  6.296E-02  5.759E-02  3.697E-02  2.704E-02  3.108E-02  2.677E-02  2.325E-02  1.768E-02  2.163E-02  5.403E-02
3.715E-02  3.484E-02  2.154E-02  1.280E-02  5.705E-03  5.636E-03  7.051E-03  8.397E-03  8.374E-03  8.146E-03  1.043E-02  1.791E-02
3.423E-03  3.491E-03  3.126E-03  1.803E-03  1.187E-03  1.574E-03  2.031E-03  2.076E-03  2.305E-03  2.510E-03  2.487E-03  3.217E-03
2.510E-04  3.651E-04  2.738E-04  7.074E-04  9.356E-04  5.476E-04  4.336E-04  5.248E-04  2.282E-04  4.336E-04  4.792E-04  3.423E-04
2.722E-02  1.602E-02  1.002E-02  1.041E-02  1.072E-02  8.466E-03  7.758E-03  5.842E-03  4.062E-03  3.149E-03  7.872E-03  1.821E-02
```

Figure A3.2 Processed meteorological data for input to PC-CREAM 08

Table A3.3 Parameters used to define Pasquill stability categories

Pasquill stability category	Wind speed (m s^{-1})	Boundary layer height (m)
A#	-	-
B	3.0	250
C	4.0	400
D	6.0	350
E	4.0	200
F	2.0	100
C Rain*	4.0	400
D Rain*	6.0	400

* A default rainfall rate of 1 mm hr^{-1} was used.
# Category A conditions not recorded in meteorological data

ASSESSOR atmospheric

The data used in the ASSESSOR atmospheric module of PC-CREAM 08 to calculate individual dose per unit release rate for discharges to atmosphere are given in Table A3.4.

Table A3.4 Input data for PC-CREAM 08 ASSESSOR atmospheric module

Parameter	Value
Stack details **Distance and angle, clockwise from north, relative to reference stack, and effective stack height.**	SZC stack 1 (south, reference stack) TM47216394 Dist = 0 m, Angle = 0°, Eff = 20 m
Stack details **Distance and angle, clockwise from north, relative to reference stack, and effective stack height.**	SZC stack 2 (north stack) TM47216417 Dist = 230 m, Angle = 0°, Eff = 20 m
Stack details **Distance and angle, clockwise from north, relative to reference stack, and effective stack height.**	SZB stack TM47356363 Dist = 340 m, Angle = 156°, Eff = 19 m
Stack details **Distance and angle, clockwise from north, relative to reference stack, and effective stack height.**	SZA stack TM47386319 Dist = 770 m, Angle = 167°, Eff = 0 m
Discharges	Unit discharge of radionuclides in Tables 1 to 3
Receptors	See Appendix 1
Ingestion rates	CEFAS study (Examples in Appendix 3)
Inhalation rates	PC-CREAM 08 defaults
Occupancy rates	CEFAS study (Examples in Appendix 3)
Time spent indoors	0% for Shoreline/beach - Plume IN (0 to 0.25km) 90% all other locations
Shielding factors	PC-CREAM 08 defaults
Delay times between food production and consumption	PC-CREAM 08 defaults
Meteorological data	See Appendix 3
Output time (y)	60

Marine dispersion modelling data

Input data used in the marine dispersion model DORIS are presented in Table A3.5. The local compartment parameter values are based on a recent review (Smith, 2019). These are not the defaults for the Sizewell site used in DORIS, as implemented in PC-CREAM 08 v1.5.1.92/2.0.0, but are updates intended to better represent local dispersion conditions. PC-CREAM 08 default values were retained for other parameters such as flow rates between regional compartments, sediment partition coefficients and concentration ratios for sea foods. The default values are based on well-established sources such as IAEA publications. Details of the data sources used can be found in HPA-RPD-[5]8 (Smith and Simmonds, 2009).

Table A3.5 Input data for marine dispersion model

Compartment	Parameter	Value
Local	Volume (m^3)	$2.00\ 10^{9}$
Local	Depth (m)	$2.00\ 10^{1}$
Local	Coastline length (m)	$1.00\ 10^{4}$
Local	Volumetric exchange rate ($m^3\ y^{-1}$)	$1.40\ 10^{10}$
Local	Suspended sediment load ($t\ m^{-3}$)	$3.65\ 10^{-5}$
Local	Sedimentation rate ($t\ m^{-2}\ y^{-1}$)	$7.00\ 10^{-4}$
Local	Sediment density ($t\ m^{-3}$)	$2.60\ 10^{0}$
Local	Diffusion coefficient ($m^{-2}\ y^{-1}$)	$3.15\ 10^{-2}$
Regional compartments	All parameters	Defaults
Common to all compartments	Concentration factors (fish, molluscs, crustaceans, seaweed)	Defaults
Common to all compartments	Sediment partition coefficients (coastal, deep water)	Defaults

ASSESSOR marine

The data used in the ASSESSOR marine module of PC-CREAM 08 to calculate individual dose per unit release rate for liquid discharges are given in Table A3.6.

Table A3.6 Input data for PC-CREAM 08 ASSESSOR marine module

Parameter	Value
Location of Assessment	Sizewell (local compartment)
Output time (y)	60
Discharges	Unit discharge of radionuclides in Tables 6 to 8
Ingestion rates	CEFAS study (Examples in Appendix 3)
Fraction of seafood caught in local compartment *	100%
Occupancy rates over sediment, handling fishing gear, exposed to sea spray	CEFAS study (Examples in Appendix 3)
Fraction of time spent in local compartment	100%
Fraction of time in local compartment spent handling fishing gear *	100% adult, 0% children and infants

*Editable for fish only in dose calculation spreadsheets

Modelling foods not included in PC-CREAM 08

Foods recorded in the CEFAS survey (Garrod et al, 2016) but not included in PC-CREAM 08 include, for the terrestrial environment, pork, poultry, eggs, wild game, mushrooms, nuts and berries and honey, and for the marine environment, wildfowl.

For the terrestrial environment, H-3 and C-14 uptake into foods is modelled using a specific activity approach in which it is assumed that the ratio of activity of H-3 per kg of water and activity of C-14 per kg of C-12 are the same in both the dispersing plume and the foodstuff. If the mass of water and C-12 in the foodstuff is known, then activities of H-3 and C-14 can be calculated. The data used for these calculations are presented in Table A3.7.

For other radionuclides in the terrestrial environment, and for which deposition onto the ground is modelled, doses from ingestion of pig and poultry products were modelled based on the assumption that they consume grain that has been grown where the animals are reared. This is a reasonable assumption because the CEFAS study indicates that some maize was grown locally for animal feed. Activity concentrations in grain were estimated using FARMLAND and appropriate ingestion rates were used to calculate the daily intake of activity by the animals. Equilibrium transfer factors, that relate activity in animal product to daily intake rate, were then used to calculate the activity concentrations in different foodstuffs. Finally, doses from ingestion of wild foods were calculated using concentration ratios and aggregated transfer factors that directly relate the concentration in the food to environmental concentrations. The environmental concentrations used depend on the transfer factors available from the literature and include the total deposited activity and activity concentrations in soil and air. Activity deposited on the ground was calculated using GRANIS; which models the transfer of radioactivity through several soil layers down to a depth of 1 metre and allows for build-up of radionuclides over time. The total deposited activity was calculated based on the radioactivity content of all soil layers in the GRANIS model. The activity concentration in soil was calculated using only those soil layers in the top 15 cm of the GRANIS model and was converted to dry weight to be more consistent with the definition of the ERICA concentration ratios. Finally, the activity concentration in air was derived from PLUME. Table A3.8 gives details of the factors used and it can be seen that data were only available for some of the radionuclides discharged from the Sizewell site.

For marine wildfowl, the approach adopted was to use activity concentrations in filtered seawater in the local compartment of the DORIS model and concentration ratios from ERICA, for the reference organism ‘marine bird’, to obtain activity concentrations in the wildfowl consumed by hunters.

Table A3.7 Data used in specific activity models to calculate activity concentrations of H-3 and C-14 in terrestrial foodstuffs not included in PC-CREAM 08

Foodstuff	Water content (%)	Carbon content (%)	Concentration in food (Bq kg-1 per Bq m-3) H-3	Concentration in food (Bq kg-1 per Bq m-3) C-14
Pork, poultry, eggs, wild game	70	12	87.5	800
Mushrooms	90	4	112.5	267
Nuts and berries	80	8	100	533
Honey	20	30	25	2000

The atmospheric specific activities are: 125.0 Bq (H-3) kg^{-1} (H_2O) per Bq m^{-3} (H-3) in air, 6667.0 Bq (C-14) kg^{-1} (C-12) per Bq m^{-3} (C-14) in air.

Table A3.8 Data used to calculate activity concentrations in terrestrial foodstuffs not included in PC-CREAM 08 for radionuclides that deposit onto the ground

Food	Units / reference	Co	Cs	I
Pork	Bq kg^{-1} per Bq d^{-1} (IAEA, 2010)	$0.2\ 10^{0}$*	$0.2\ 10^{0}$	$4.1\ 10^{-2}$
Poultry	Bq kg^{-1} per Bq d^{-1} (IAEA, 2010)	$9.7\ 10^{-1}$	$2.7\ 10^{0}$	$8.7\ 10^{-3}$
Eggs	Bq kg^{-1} per Bq d^{-1} (IAEA, 2010)	$3.3\ 10^{-2}$	$0.4\ 10^{0}$	$2.4\ 10^{0}$
Wild game	Bq kg^{-1} fw / Bq kg^{-1} soil dry wt (Brown et al, 2016)	$1.3\ 10^{-2}$	$5.6\ 10^{-1}$	$4.0\ 10^{-1}$

Food	Units / reference	Co	Cs	I
Mushrooms	Bq kg^{-1} fw / Bq m^{-2} (IAEA, 2010) (IAEA and CEC, 1993)	5.0 10^{-1}	5.0 10^{-1}	2.5 10^{0}
Nuts and berries	Bq kg^{-1} fw / Bq m^{-2} (IAEA, 2010) (IAEA and CEC, 1993)	1.8 10^{-2}	1.8 10^{-2}	9.0 10^{-2}
Honey	Bq kg^{-1} fw / Bq m^{-2} (IAEA, 2010) (IAEA and CEC, 1993)	-	2.3 10^{-2}	-

* Based on review of data in (Ng et al, 1982)

Mapping CEFAS exposure pathways to those in PC-CREAM 08

The CEFAS habit survey for Sizewell includes some exposure pathways that are not included in PC-CREAM 08. Tables A3.9 and A3.10 show how the CEFAS pathways were mapped to those in PC-CREAM 08 and the alternative methods adopted to model exposures where PC-CREAM 08 could not be used.

Table A3.9 Mapping of CEFAS exposure pathways to those in PC-CREAM 08 for terrestrial environment

CEFAS exposure pathway	Mapping
Eggs	For H and C: PC-CREAM 08 activity concentration in air at allotments Specific activity ratios: 87.5 Bq (H-3) kg^{-1} fw (H_2O) per Bq m^{-3} (H-3) in air 800 Bq (C-14) kg^{-1} fw (C-12) per Bq m^{-3} (C-14) in air PC-CREAM 08 ingestion dose coefficients (Smith and Simmonds, 2009) For all other radionuclides: PC-CREAM 08 activity concentration in grain at allotments BCIS grain intake rate (BCIS, 1990; IAEA, 2010) IAEA TRS472 transfer factors (IAEA, 2010) PC-CREAM 08 ingestion dose coefficients (Smith and Simmonds, 2009)
Fruit – domestic	PC-CREAM 08 fruit at allotments
Fruit and nuts – wild	For H and C:

CEFAS exposure pathway	Mapping
	PC-CREAM 08 activity concentration in air at open access land Specific activity ratios: 100 Bq (H-3) kg^{-1} fw (H_2O) per Bq m^{-3} (H-3) in air 533 Bq (C-14) kg^{-1} fw (C-12) per Bq m^{-3} (C-14) in air PC-CREAM 08 ingestion dose coefficients (Smith and Simmonds, 2009) For all other radionuclides: PC-CREAM 08 activity on ground at open access land IAEA TRS472 aggregated transfer factor for berries (converted to fresh weight) (IAEA, 2010) PC-CREAM 08 ingestion dose coefficients (Smith and Simmonds, 2009)
Honey	For H and C only: PC-CREAM 08 activity concentration in air at allotments Specific activity ratios: 25 Bq (H-3) kg^{-1} fw (H_2O) per Bq m^{-3} (H-3) in air 2002.5 Bq (C-14) kg^{-1} fw (C-12) per Bq m^{-3} (C-14) in air PC-CREAM 08 ingestion dose coefficients (Smith and Simmonds, 2009) For Cs: PC CREAM 08 activity on ground at allotments IAEA TRS472 aggregated transfer factor for honey (converted to fresh weight) (IAEA, 2010) PC-CREAM ingestion dose coefficients (Smith and Simmonds, 2009)
Meat – cow	PC-CREAM 08 cow meat at salt marsh PC-CREAM 08 cow liver at salt marsh PC-CREAM 08 fraction of intake that is liver
Meat – game	For H and C: PC-CREAM 08 activity concentration in air at open access land Specific activity ratios: 87.5 Bq (H-3) kg^{-1} fw (H_2O) per Bq m^{-3} (H-3) in air 800 Bq (C-14) kg^{-1} fw (C-12) per Bq m^{-3} (C-14) in air PC-CREAM 08 ingestion dose coefficients (Smith and Simmonds, 2009)

CEFAS exposure pathway	Mapping
	For all other radionuclides: PC-CREAM 08 activity concentration in soil (15 cm) at open access land ERICA concentration ratio for large terrestrial mammal (Brown et al, 2016) PC-CREAM 08 ingestion dose coefficients (Smith and Simmonds, 2009)
Meat – pig	For H and C: PC-CREAM 08 activity concentration in air at salt marsh Specific activity ratios: 87.5 Bq (H-3) kg^{-1} fw (H_2O) per Bq m^{-3} (H-3) in air 800 Bq (C-14) kg^{-1} fw (C-12) per Bq m^{-3} (C-14) in air PC-CREAM 08 ingestion dose coefficients (Smith and Simmonds, 2009) For all other radionuclides: PC-CREAM 08 activity concentration in grain at salt marsh NRPB-R299 grain intake rate (Nisbet and Woodman, 1998) IAEA TRS472 transfer factors (IAEA, 2010) PC-CREAM 08 ingestion dose coefficients (Smith and Simmonds, 2009)
Meat – poultry	For H and C: PC-CREAM 08 activity concentration in air at allotments Specific activity ratios: 87.5 Bq (H-3) kg^{-1} fw (H_2O) per Bq m^{-3} (H-3) in air 800 Bq (C-14) kg^{-1} fw (C-12) per Bq m^{-3} (C-14) in air PC-CREAM ingestion dose coefficients (Smith and Simmonds, 2009) For all other radionuclides: PC-CREAM 08 activity concentration in grain at allotments BCIS grain intake rate (BCIS, 1990; IAEA, 2010) IAEA TRS472 transfer factors (IAEA, 2010) PC-CREAM ingestion dose coefficients (Smith and Simmonds, 2009)
Meat – sheep	PC-CREAM 08 sheep meat at salt marsh

CEFAS exposure pathway	Mapping
	PC-CREAM 08 sheep liver at salt marsh PC-CREAM 08 fraction of intake that is liver
Mushrooms	For H and C: PC-CREAM 08 activity concentration in air at open access land Specific activity ratios: 112.5 Bq (H-3) kg^{-1} fw (H_2O) per Bq m^{-3} (H-3) in air 267 Bq (C-14) kg^{-1} fw (C-12) per Bq m^{-3} (C-14) in air PC-CREAM 08 ingestion dose coefficients (Smith and Simmonds, 2009) For all other radionuclides: PC-CREAM 08 activity on ground at open access land IAEA TRS472 aggregated transfer factor for fungi (converted to fresh weight) (IAEA, 2010) PC-CREAM 08 ingestion dose coefficients (Smith and Simmonds, 2009)
Plume IN	PC-CREAM 08 inhalation of plume at shoreline PC-CREAM 08 gamma from plume at shoreline PC-CREAM 08 beta from plume at shoreline PC-CREAM 08 gamma from ground at shoreline PC-CREAM 08 beta from ground at shoreline PC-CREAM 08 resuspension at shoreline
Plume MID	PC-CREAM 08 inhalation of plume at local housing PC-CREAM 08 gamma from plume at local housing PC-CREAM 08 beta from plume at local housing PC-CREAM 08 gamma from ground at local housing PC-CREAM 08 beta from ground at local housing PC-CREAM 08 resuspension at local housing
Plume OUT	PC-CREAM 08 inhalation of plume at leisure facility PC-CREAM 08 gamma from plume at leisure facility PC-CREAM 08 beta from plume at leisure facility PC-CREAM 08 gamma from ground at leisure facility PC-CREAM 08 beta from ground at leisure facility PC-CREAM 08 resuspension at leisure facility
Vegetables – green	PC-CREAM 08 green vegetables at allotments

CEFAS exposure pathway	Mapping
Vegetables – other domestic	PC-CREAM 08 green vegetables at allotments
Vegetables – potatoes	PC-CREAM 08 root vegetables at allotments
Vegetables – root	PC-CREAM 08 root vegetables at allotments

Table A3.10 Mapping of CEFAS exposure pathways to those in PC-CREAM 08 for marine environment

CEFAS exposure pathway	Mapping
Crustacea	PC-CREAM 08 crustaceans, local compartment
Fish - Sea	PC-CREAM 08 fish, local compartment PC-CREAM 08 fish, regional compartment
Gamma external - Houseboat	Exposure over sediments: Over sediment 67% of the time (NNB GenCo (SZC), 2020)† PC-CREAM 08 external beta from beaches PC-CREAM 08 external gamma from beaches Shielding factor of 0.75 for houseboat hull (Environment Agency, 2011) Exposure from immersion in water: Over water 33% of the time (NNB GenCo (SZC), 2020) PC-CREAM 08 activity concentration in unfiltered seawater FGR15 dose coefficients for immersion in water (US EPA, 2019)‡ Dose reduction factor of 0.5 for occupancy at air-water interface (US EPA, 2019) Shielding factor of 0.75 for houseboat hull (Environment Agency, 2011)
Gamma external - Salt marsh	PC-CREAM 08 external beta from beaches PC-CREAM 08 external gamma from beaches
Gamma external - Sediments	PC-CREAM 08 external beta from beaches PC-CREAM 08 external gamma from beaches PC-CREAM 08 external beta from fishing gear PC-CREAM 08 external gamma from fishing gear Fraction of time spent on sediment also spent handling fishing gear (default = 1 for adult, 0 for child, 0 for infant)*

CEFAS exposure pathway	Mapping
Marine plants/algae	PC-CREAM 08 seaweed
Meat - Wildfowl	PC-CREAM 08 activity concentration in filtered seawater ERICA concentration ratios for marine bird (Brown et al, 2016) PC-CREAM 08 ingestion dose coefficients (Smith and Simmonds, 2009)
Mollusca	PC-CREAM 08 molluscs
Occupancy IN water	PC-CREAM 08 activity concentration in unfiltered seawater FGR15 dose coefficients for immersion in water (US EPA, 2019)‡
Occupancy ON water	PC-CREAM 08 activity concentration in unfiltered seawater FGR15 dose coefficients for immersion in water (US EPA, 2019)‡ Dose reduction factor of 0.5 for occupancy at air-water interface (US EPA, 2019)

* Editable variables
† The houseboat is assumed to be moored towards the high water mark of an estuary (NNB GenCo (SZC), 2020) and consequently sits on sediment for two-thirds of the time and over water for the remaining third.
‡ Contribution from progeny is explicitly calculated in the workbook since FGR15 dose rate coefficients do not include progeny.

Habit data for selected CRPs

The CEFAS habit survey for the Sizewell site includes a series of habits profiles for adults, children, infants and women of childbearing age. The habits profiles include information on the important habits that may lead to exposure to radionuclides in the marine environment (from liquid discharges) and in the terrestrial environment (from discharges to atmosphere) and direct radiation. The habits profiles are derived such that they represent those members of the public likely to be most exposed to radiation from the Sizewell site. The habits profiles can therefore be used as candidates for the representative person (CRP) and in the calculation of doses to identify the representative person.

The habits data profiles presented in Table A3.11 are taken from the CEFAS habit survey for the Sizewell site (Garrod et al, 2016). The habits profiles giving the highest dose for each age category are presented. These profiles are the more exposed candidates for the representative person (CRP) to liquid discharges and to discharges to atmosphere. For liquid discharges these habits profiles are adult sea fish consumers; child mollusc consumers; infant sea fish consumers and fetus (women of child bearing age have been used to calculate doses to the fetus using the method described in (HPA, 2008). For discharges to atmosphere the habits profiles are adults and children who live close to the site and infant green vegetable consumers.

Table A3.11 Habits profiles for the more exposed Candidate for Representative Person (CRP) for each age group and discharge route

Pathway	Units	Liquid discharges: Adult Sea Fish Consumers	Liquid discharges: Child Mollusc Consumers	Liquid discharges: Infant Sea Fish Consumers	Liquid discharges: Fetus Crustacean consumers	Discharges to atmosphere: Adult Plume IN 0 to 0.25 km	Discharges to atmosphere: Child Plume MID 0.5 to 1 km	Discharges to atmosphere: Infant Green vegetable consumers
Crustacean	kg y^{-1}	0.71	0.23	0	12.1	0.15	0.72	0
Eggs	kg y^{-1}	0	0	0	0	12.2	1.8	0
Fish – Sea	kg y^{-1}	23.5	17	7.4	2	7.9	2.9	0
Fruit – Domestic	kg y^{-1}	2	0	0	0	4.2	2.9	3.8
Fruit and nuts – Wild	kg y^{-1}	0.06	0	0	0	2	1.6	0.17
Gamma external – Houseboat	h y^{-1}	0	0	0	0	0	0	0
Gamma external – Salt marsh	h y^{-1}	23	0	0	0	<1	0	0
Gamma external – Sediments	h y^{-1}	180	0	0	0	260	140	0
Honey	kg y^{-1}	0	0	0	0	0	0	0
Marine plants/algae	kg y^{-1}	0	0	0	0	0	0	0
Meat – Cow	kg y^{-1}	0	0	0	0	0	0	0
Meat – Game	kg y^{-1}	0	0	0	0	0.05	0	0
Meat – Pig	kg y^{-1}	0	0	0	0	0	0	0
Meat – Poultry	kg y^{-1}	0.29	0	0	0	0.4	0	0

Pathway	Units	Liquid discharges: Adult Sea Fish Consumers	Liquid discharges: Child Mollusc Consumers	Liquid discharges: Infant Sea Fish Consumers	Liquid discharges: Fetus Crustacean consumers	Discharges to atmosphere: Adult Plume IN 0 to 0.25 km	Discharges to atmosphere: Child Plume MID 0.5 to 1 km	Discharges to atmosphere: Infant Green vegetable consumers
Meat – Sheep	kg y^{-1}	0	0	0	0	0	0	0
Meat – Wildfowl	kg y^{-1}	0	0	0	0	0.4	0	0
Mollusca	kg y^{-1}	0.09	0.79	0	0	0	0	0
Mushrooms	kg y^{-1}	0	0	0	0	0	0	0
Occupancy in water	h y^{-1}	1	0	0	0	4	0	0
Occupancy on water	h y^{-1}	270	0	0	0	160	0	0
Plume IN (0-0.25km)	h y^{-1}	190 *	0	0	0	6870 #	0	0
Plume MID (0.25-0.5km)	h y^{-1}	220 #	0	0	0	0	0	0
Plume OUT (>0.5-1km)	h y^{-1}	0	0	0	0	0	6160 #	0
Vegetables – Green	kg y^{-1}	3.9	0	0	0	0	8.5	9.1
Vegetables – Other Domestic	kg y^{-1}	2.7	0	0	0	2.1	0	3.3
Vegetables – Potatoes	kg y^{-1}	7.2	0	0	0	4.8	1	7.5
Vegetables – Root	kg y^{-1}	3.8	0	0	0	4	3.2	5.3

* Indoor occupancy assumed to be 0% for this profile while at this location
# Indoor occupancy assumed to be 90% for this profile while at this location

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Appendix 4 Environmental activity concentrations for SZC permitted discharges

This appendix presents calculated activity concentrations in the terrestrial and marine environments at the locations where dose assessments are carried out. The results are for SZC discharges at permitted limits (Tables A4.1 to A4.15).

Table A4.1 Activity concentrations in air (Bq m^{-3}) for discharges to atmosphere from SZC at proposed limits

Location	Ar-41	C-14	Co-58	Co-60	Cs-134	Cs-137	Ba-137m (Cs-137)	H-3	I-131	Xe-131m (I-131)
Allotments	$2.8\ 10^{-3}$	$3.2\ 10^{-3}$	$6.8\ 10^{-8}$	$8.1\ 10^{-8}$	$6.3\ 10^{-8}$	$5.6\ 10^{-8}$	$5.0\ 10^{-8}$	$1.4\ 10^{-2}$	$8.2\ 10^{-7}$	$3.5\ 10^{-10}$
Salt marsh south of Minsmere	$1.7\ 10^{-2}$	$1.9\ 10^{-2}$	$4.1\ 10^{-7}$	$4.8\ 10^{-7}$	$3.8\ 10^{-7}$	$3.4\ 10^{-7}$	$2.1\ 10^{-7}$	$8.1\ 10^{-2}$	$5.2\ 10^{-6}$	$8.5\ 10^{-10}$
Open Access land	$7.4\ 10^{-3}$	$8.2\ 10^{-3}$	$1.8\ 10^{-7}$	$2.1\ 10^{-7}$	$1.6\ 10^{-7}$	$1.5\ 10^{-7}$	$1.1\ 10^{-7}$	$3.5\ 10^{-2}$	$2.2\ 10^{-6}$	$4.8\ 10^{-10}$
Shoreline/ beach	$8.3\ 10^{-2}$	$8.9\ 10^{-2}$	$2.0\ 10^{-6}$	$2.3\ 10^{-6}$	$1.8\ 10^{-6}$	$1.6\ 10^{-6}$	$4.7\ 10^{-7}$	$3.8\ 10^{-1}$	$2.5\ 10^{-5}$	$1.3\ 10^{-9}$
Local housing	$7.1\ 10^{-3}$	$7.7\ 10^{-3}$	$1.7\ 10^{-7}$	$2.0\ 10^{-7}$	$1.5\ 10^{-7}$	$1.4\ 10^{-7}$	$8.8\ 10^{-8}$	$3.3\ 10^{-2}$	$2.1\ 10^{-6}$	$3.6\ 10^{-10}$
Leisure facility	$3.9\ 10^{-3}$	$4.3\ 10^{-3}$	$9.3\ 10^{-8}$	$1.1\ 10^{-7}$	$8.5\ 10^{-8}$	$7.6\ 10^{-8}$	$5.9\ 10^{-8}$	$1.8\ 10^{-2}$	$1.1\ 10^{-6}$	$3.1\ 10^{-10}$
Generic location 250 m north of north stack	$7.9\ 10^{-2}$	$8.6\ 10^{-2}$	$1.9\ 10^{-6}$	$2.2\ 10^{-6}$	$1.7\ 10^{-6}$	$1.5\ 10^{-6}$	$3.4\ 10^{-7}$	$3.7\ 10^{-1}$	$2.4\ 10^{-5}$	$9.2\ 10^{-10}$
Generic location 500 m north of north stack	$4.7\ 10^{-2}$	$5.0\ 10^{-2}$	$1.1\ 10^{-6}$	$1.3\ 10^{-6}$	$1.0\ 10^{-6}$	$9.0\ 10^{-7}$	$3.3\ 10^{-7}$	$2.2\ 10^{-1}$	$1.4\ 10^{-5}$	$1.0\ 10^{-9}$

Table A4.1 continued

Location	I-133	Xe-133 (I-133)	Xe-133m (I-133)	Kr-85	Xe-131m	Xe-133	Xe-135	Cs-135 (Xe-135)
Allotments	$9.8\ 10^{-7}$	$9.4\ 10^{-10}$	$2.3\ 10^{-9}$	$1.4\ 10^{-2}$	3.0 10-4	$6.4\ 10^{-2}$	$2.0\ 10^{-2}$	$1.1\ 10^{-13}$
Salt marsh south of Minsmere	$6.2\ 10^{-6}$	$2.3\ 10^{-9}$	$5.5\ 10^{-9}$	$8.5\ 10^{-2}$	$1.8\ 10^{-3}$	$3.8\ 10^{-1}$	$1.2\ 10^{-1}$	$2.7\ 10^{-13}$
Open Access land	$2.7\ 10^{-6}$	$1.3\ 10^{-9}$	$3.1\ 10^{-9}$	$3.7\ 10^{-2}$	7.9 10-4	$1.7\ 10^{-1}$	$5.2\ 10^{-2}$	$1.5\ 10^{-13}$
Shoreline/ beach	$3.0\ 10^{-5}$	$3.6\ 10^{-9}$	$8.6\ 10^{-9}$	$4.0\ 10^{-1}$	$8.6\ 10^{-3}$	$1.8\ 10^{0}$	$5.7\ 10^{-1}$	$4.2\ 10^{-13}$
Local housing	$2.5\ 10^{-6}$	$9.8\ 10^{-10}$	$2.3\ 10^{-9}$	$3.5\ 10^{-2}$	7.5 10-4	$1.6\ 10^{-1}$	$4.9\ 10^{-2}$	$1.2\ 10^{-13}$
Leisure facility	$1.4\ 10^{-6}$	$8.2\ 10^{-10}$	$2.0\ 10^{-9}$	$1.9\ 10^{-2}$	4.1 10-4	$8.7\ 10^{-2}$	$2.7\ 10^{-2}$	$9.9\ 10^{-14}$
Generic location 250 m north of north stack	$2.9\ 10^{-5}$	$2.5\ 10^{-9}$	$5.9\ 10^{-9}$	$3.8\ 10^{-1}$	$8.2\ 10^{-3}$	$1.7\ 10^{0}$	$5.4\ 10^{-1}$	$2.9\ 10^{-13}$
Generic location 500 m north of north stack	$1.7\ 10^{-5}$	$2.7\ 10^{-9}$	$6.5\ 10^{-9}$	$2.2\ 10^{-1}$	$4.9\ 10^{-3}$	$1.0\ 10^{0}$	$3.2\ 10^{-1}$	$3.2\ 10^{-13}$

Table A4.2 Deposition rates (Bq m^{-2} s^{-1}) for expected discharges to atmosphere from SZC at proposed limits

Location	Ar-41	C-14	Co-58	Co-60	Cs-134	Cs-137	Ba-137m (Cs-137)	H-3	I-131	Xe-131m (I-131)
Allotments	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.3\ 10^{-10}$	$1.5\ 10^{-10}$	$1.2\ 10^{-10}$	$1.1\ 10^{-10}$	$9.2\ 10^{-11}$	$0.0\ 10^{0}$	$9.0\ 10^{-9}$	$0.0\ 10^{0}$
Salt marsh south of Minsmere	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$8.0\ 10^{-10}$	$9.5\ 10^{-10}$	$7.4\ 10^{-10}$	$6.6\ 10^{-10}$	$3.9\ 10^{-10}$	$0.0\ 10^{0}$	$5.7\ 10^{-8}$	$0.0\ 10^{0}$
Open Access land	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.9\ 10^{-10}$	$3.5\ 10^{-10}$	$2.7\ 10^{-10}$	$2.4\ 10^{-10}$	$1.6\ 10^{-10}$	$0.0\ 10^{0}$	$2.4\ 10^{-8}$	$0.0\ 10^{0}$
Shoreline/ beach	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.7\ 10^{-9}$	$3.2\ 10^{-9}$	$2.5\ 10^{-9}$	$2.2\ 10^{-9}$	$6.3\ 10^{-10}$	$0.0\ 10^{0}$	$2.6\ 10^{-7}$	$0.0\ 10^{0}$
Local housing	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.6\ 10^{-10}$	$4.2\ 10^{-10}$	$3.3\ 10^{-10}$	$2.9\ 10^{-10}$	$1.7\ 10^{-10}$	$0.0\ 10^{0}$	$2.4\ 10^{-8}$	$0.0\ 10^{0}$
Leisure facility	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.2\ 10^{-10}$	$2.6\ 10^{-10}$	$2.0\ 10^{-10}$	$1.8\ 10^{-10}$	$1.3\ 10^{-10}$	$0.0\ 10^{0}$	$1.3\ 10^{-8}$	$0.0\ 10^{0}$
Generic location 250 m north of north stack	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.3\ 10^{-9}$	$3.9\ 10^{-9}$	$3.1\ 10^{-9}$	$2.7\ 10^{-9}$	$5.6\ 10^{-10}$	$0.0\ 10^{0}$	$2.6\ 10^{-7}$	$0.0\ 10^{0}$
Generic location 500 m north of north stack	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.9\ 10^{-9}$	$2.2\ 10^{-9}$	$1.7\ 10^{-9}$	$1.6\ 10^{-9}$	$5.4\ 10^{-10}$	$0.0\ 10^{0}$	$1.5\ 10^{-7}$	$0.0\ 10^{0}$

Table A4.2 continued

Location	I-133	Xe-133 (I-133)	Xe-133m (I-133)	Kr-85	Xe-131m	Xe-133	Xe-135	Cs-135 (Xe-135)
Allotments	$1.1\ 10^{-8}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.8\ 10^{-16}$
Salt marsh south of Minsmere	$6.8\ 10^{-8}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$4.6\ 10^{-16}$
Open Access land	$2.8\ 10^{-8}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.2\ 10^{-16}$
Shoreline/ beach	$3.1\ 10^{-7}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$5.6\ 10^{-16}$
Local housing	$2.8\ 10^{-8}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.1\ 10^{-16}$
Leisure facility	$1.6\ 10^{-8}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.9\ 10^{-16}$
Generic location 250 m north of north stack	$3.1\ 10^{-7}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$4.8\ 10^{-16}$
Generic location 500 m north of north stack	$1.8\ 10^{-7}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$5.1\ 10^{-16}$

Table A4.3 Annual average activity concentrations in soil layers (Bq kg^{-1}) in 60th year of operation for expected discharges to atmosphere from SZC at proposed limits$^{@}$ - Allotments.

Soil layers (m)	Co-58	Co-60	Cs-134	Cs-137	Ba-137m*	Ba-137m (Cs-137)$^{\#}$	I-131	Xe-131m*	I-133	Xe-133*	Cs-135 (Xe-135)$^{\#}$
0 - 0.01	$7.2\ 10^{-5}$	$8.6\ 10^{-4}$	$4.3\ 10^{-4}$	$8.4\ 10^{-4}$	$8.4\ 10^{-4}$	$1.4\ 10^{-9}$	$6.0\ 10^{-4}$	$5.9\ 10^{-4}$	$7.7\ 10^{-5}$	$7.6\ 10^{-5}$	$1.6\ 10^{-9}$
0.01 - 0.05	$1.2\ 10^{-6}$	$2.7\ 10^{-4}$	$6.6\ 10^{-5}$	$5.9\ 10^{-4}$	$5.9\ 10^{-4}$	$5.8\ 10^{-16}$	$1.1\ 10^{-6}$	$2.8\ 10^{-6}$	$1.6\ 10^{-8}$	$1.1\ 10^{-7}$	$1.5\ 10^{-9}$
0.05 - 0.15	$8.3\ 10^{-9}$	$4.0\ 10^{-5}$	$4.4\ 10^{-6}$	$2.2\ 10^{-4}$	$2.2\ 10^{-4}$	1.0 10-^{22}	$9.2\ 10^{-10}$	$4.3\ 10^{-9}$	$1.4\ 10^{-12}$	$6.0\ 10^{-11}$	$7.5\ 10^{-10}$
0.15 - 0.3	$6.0\ 10^{-11}$	$7.0\ 10^{-6}$	$3.3\ 10^{-7}$	$1.0\ 10^{-4}$	$1.0\ 10^{-4}$	$1.9\ 10^{-29}$	$7.6\ 10^{-13}$	$6.0\ 10^{-12}$	$1.2\ 10^{-16}$	$3.2\ 10^{-14}$	$4.2\ 10^{-10}$
0.3 - 1	$5.0\ 10^{-14}$	$1.6\ 10^{-7}$	$2.9\ 10^{-9}$	$4.9\ 10^{-6}$	$4.9\ 10^{-6}$	$3.9\ 10^{-37}$	$7.2\ 10^{-17}$	$9.1\ 10^{-16}$	$1.3\ 10^{-21}$	$2.0\ 10^{-18}$	$2.4\ 10^{-11}$

Table A4.4 Annual average activity concentrations in soil layers (Bq kg^{-1}) in 60th year of operation for expected discharges to atmosphere from SZC at proposed limits$^{@}$ - Salt marsh south of Minsmere.

Soil layers (m)	Co-58	Co-60	Cs-134	Cs-137	Ba-137m*	Ba-137m (Cs-137)$^{\#}$	I-131	Xe-131m*	I-133	Xe-133*	Cs-135 (Xe-135)$^{\#}$
0 - 0.01	$4.4\ 10^{-4}$	$5.3\ 10^{-3}$	$2.7\ 10^{-3}$	$5.2\ 10^{-3}$	$5.2\ 10^{-3}$	$5.7\ 10^{-9}$	$3.8\ 10^{-3}$	$3.7\ 10^{-3}$	$4.9\ 10^{-4}$	$4.8\ 10^{-4}$	$4.0\ 10^{-9}$
0.01 - 0.05	$7.4\ 10^{-6}$	$1.7\ 10^{-3}$	$4.1\ 10^{-4}$	$3.6\ 10^{-3}$	$3.6\ 10^{-3}$	$2.4\ 10^{-15}$	$7.3\ 10^{-6}$	$1.8\ 10^{-5}$	$1.0\ 10^{-7}$	$7.1\ 10^{-7}$	$3.7\ 10^{-9}$
0.05 - 0.15	$5.1\ 10^{-8}$	$2.5\ 10^{-4}$	$2.7\ 10^{-5}$	$1.4\ 10^{-3}$	$1.4\ 10^{-3}$	$4.3\ 10^{-22}$	$5.8\ 10^{-9}$	$2.7\ 10^{-8}$	$8.7\ 10^{-12}$	$3.8\ 10^{-10}$	$1.9\ 10^{-9}$
0.15 - 0.3	3.7 10-10	$4.3\ 10^{-5}$	$2.0\ 10^{-6}$	$6.2\ 10^{-4}$	$6.2\ 10^{-4}$	$7.8\ 10^{-29}$	$4.8\ 10^{-12}$	$3.8\ 10^{-11}$	$7.8\ 10^{-16}$	$2.1\ 10^{-13}$	$1.1\ 10^{-9}$
0.3 - 1	$3.1\ 10^{-13}$	$9.6\ 10^{-7}$	$1.8\ 10^{-8}$	$3.0\ 10^{-5}$	$3.0\ 10^{-5}$	$1.6\ 10^{-36}$	$4.5\ 10^{-16}$	$5.7\ 10^{-15}$	$7.9\ 10^{-21}$	1.3 10-17	$5.9\ 10^{-11}$

Table A4.5 Annual average activity concentrations in soil layers (Bq kg^{-1}) in 60th year of operation for expected discharges to atmosphere from SZC at proposed limits$^{@}$ - Open Access land.

Soil layers (m)	Co-58	Co-60	Cs-134	Cs-137	Ba-137m*	Ba-137m (Cs-137)$^{\#}$	I-131	Xe-131m*	I-133	Xe-133*	Cs-135 (Xe-135)$^{\#}$
0 - 0.01	$1.6\ 10^{-4}$	$1.9\ 10^{-3}$	$9.8\ 10^{-4}$	$1.9\ 10^{-3}$	$1.9\ 10^{-3}$	$2.4\ 10^{-9}$	$1.6\ 10^{-3}$	$1.6\ 10^{-3}$	$2.0\ 10^{-4}$	$2.0\ 10^{-4}$	$1.9\ 10^{-9}$

Soil layers (m)	Co-58	Co-60	Cs-134	Cs-137	Ba-137m*	Ba-137m (Cs-137)#	I-131	Xe-131m*	I-133	Xe-133*	Cs-135 (Xe-135)#
0.01 - 0.05	2.7 10^{-6}	6.1 10^{-4}	1.5 10^{-4}	1.3 10^{-3}	1.3 10^{-3}	1.0 10^{-15}	3.0 10^{-6}	7.5 10^{-6}	4.2 10^{-8}	3.0 10^{-7}	1.8 10^{-9}
0.05 - 0.15	1.9 10^{-8}	9.0 10^{-5}	1.0 10^{-5}	5.0 10^{-4}	5.0 10^{-4}	1.8 10^{-22}	2.4 10^{-9}	1.1 10^{-8}	3.6 10^{-12}	1.6 10^{-10}	9.1 10^{-10}
0.15 - 0.3	1.4 10^{-10}	1.6 10^{-5}	7.4 10^{-7}	2.3 10^{-4}	2.3 10^{-4}	3.3 10^{-29}	2.0 10^{-12}	1.6 10^{-11}	3.3 10^{-16}	8.6 10^{-14}	5.1 10^{-10}
0.3 - 1	1.1 10^{-13}	3.5 10^{-7}	6.6 10^{-9}	1.1 10^{-5}	1.1 10^{-5}	6.9 10^{-37}	1.9 10^{-16}	2.4 10^{-15}	3.3 10^{-21}	5.3 10^{-18}	2.9 10^{-11}

Table A4.6 Annual average activity concentrations in soil layers (Bq kg^{-1}) in 60th year of operation for expected discharges to atmosphere from SZC at proposed limits@ - Shoreline/beach.

Soil layers (m)	Co-58	Co-60	Cs-134	Cs-137	Ba-137m*	Ba-137m (Cs-137)#	I-131	Xe-131m*	I-133	Xe-133*	Cs-135 (Xe-135)#
0 - 0.01	1.5 10^{-3}	1.8 10^{-2}	9.1 10^{-3}	1.8 10^{-2}	1.8 10^{-2}	9.2 10^{-9}	1.7 10^{-2}	1.7 10^{-2}	2.3 10^{-3}	2.2 10^{-3}	4.8 10^{-9}
0.01 - 0.05	2.5 10^{-5}	5.6 10^{-3}	1.4 10^{-3}	1.2 10^{-2}	1.2 10^{-2}	3.9 10^{-15}	3.3 10^{-5}	8.2 10^{-5}	4.7 10^{-7}	3.3 10^{-6}	4.5 10^{-9}
0.05 - 0.15	1.7 10^{-7}	8.3 10^{-4}	9.3 10^{-5}	4.6 10^{-3}	4.6 10^{-3}	6.9 10^{-22}	2.7 10^{-8}	1.2 10^{-7}	4.0 10^{-11}	1.7 10^{-9}	2.3 10^{-9}
0.15 - 0.3	1.3 10^{-9}	1.5 10^{-4}	6.8 10^{-6}	2.1 10^{-3}	2.1 10^{-3}	1.3 10^{-28}	2.2 10^{-11}	1.7 10^{-10}	3.6 10^{-15}	9.5 10^{-13}	1.3 10^{-9}
0.3 - 1	1.0 10^{-12}	3.3 10^{-6}	6.1 10^{-8}	1.0 10^{-4}	1.0 10^{-4}	2.6 10^{-36}	2.1 10^{-15}	2.6 10^{-14}	3.7 10^{-20}	5.9 10^{-17}	7.2 10^{-11}

Table A4.7 Annual average activity concentrations in soil layers (Bq kg^{-1}) in 60th year of operation for expected discharges to atmosphere from SZC at proposed limits@ - Local housing.

Soil layers (m)	Co-58	Co-60	Cs-134	Cs-137	Ba-137m*	Ba-137m (Cs-137)#	I-131	Xe-131m*	I-133	Xe-133*	Cs-135 (Xe-135)#
0 - 0.01	2.0 10^{-4}	2.3 10^{-3}	1.2 10^{-3}	2.3 10^{-3}	2.3 10^{-3}	2.6 10^{-9}	1.6 10^{-3}	1.5 10^{-3}	2.0 10^{-4}	2.0 10^{-4}	1.8 10^{-9}
0.01 - 0.05	3.3 10^{-6}	7.4 10^{-4}	1.8 10^{-4}	1.6 10^{-3}	1.6 10^{-3}	1.1 10^{-15}	3.0 10^{-6}	7.4 10^{-6}	4.2 10^{-8}	3.0 10^{-7}	1.7 10^{-9}
0.05 - 0.15	2.3 10^{-8}	1.1 10^{-4}	1.2 10^{-5}	6.0 10^{-4}	6.0 10^{-4}	1.9 10^{-22}	2.4 10^{-9}	1.1 10^{-8}	3.6 10^{-12}	1.6 10^{-10}	8.6 10^{-10}
0.15 - 0.3	1.6 10^{-10}	1.9 10^{-5}	8.9 10^{-7}	2.7 10^{-4}	2.7 10^{-4}	3.5 10^{-29}	2.0 10^{-12}	1.6 10^{-11}	3.2 10^{-16}	8.5 10^{-14}	4.9 10^{-10}
0.3 - 1	1.4 10^{-13}	4.3 10^{-7}	7.9 10^{-9}	1.3 10^{-5}	1.3 10^{-5}	7.3 10^{-37}	1.9 10^{-16}	2.4 10^{-15}	3.3 10^{-21}	5.3 10^{-18}	2.7 10^{-11}

Table A4.8 Annual average activity concentrations in soil layers (Bq kg^{-1}) in 60^{th} year of operation for expected discharges to atmosphere from SZC at proposed limits$^{@}$ - Leisure facility.

Soil layers (m)	Co-58	Co-60	Cs-134	Cs-137	Ba-137m*	Ba-137m (Cs-137)#	I-131	Xe-131m*	I-133	Xe-133*	Cs-135 (Xe-135)#
0 - 0.01	1.2 10^{-4}	1.4 10^{-3}	7.3 10^{-4}	1.4 10^{-3}	1.4 10^{-3}	1.9 10^{-9}	8.7 10^{-4}	8.6 10^{-4}	1.1 10^{-4}	1.1 10^{-4}	1.7 10^{-9}
0.01 - 0.05	2.0 10^{-6}	4.5 10^{-4}	1.1 10^{-4}	9.9 10^{-4}	9.9 10^{-4}	8.2 10^{-16}	1.7 10^{-6}	4.1 10^{-6}	2.3 10^{-8}	1.6 10^{-7}	1.6 10^{-9}
0.05 - 0.15	1.4 10^{-8}	6.7 10^{-5}	7.4 10^{-6}	3.7 10^{-4}	3.7 10^{-4}	1.5 10^{-22}	1.3 10^{-9}	6.2 10^{-9}	2.0 10^{-12}	8.7 10^{-11}	7.9 10^{-10}
0.15 - 0.3	1.0 10^{-10}	1.2 10^{-5}	5.5 10^{-7}	1.7 10^{-4}	1.7 10^{-4}	2.6 10^{-29}	1.1 10^{-12}	8.7 10^{-12}	1.8 10^{-16}	4.7 10^{-14}	4.4 10^{-10}
0.3 - 1	8.5 10^{-14}	2.6 10^{-7}	4.9 10^{-9}	8.3 10^{-6}	8.3 10^{-6}	5.5 10^{-37}	1.0 10^{-16}	1.3 10^{-15}	1.8 10^{-21}	2.9 1^{0-18}	2.5 10^{-11}

Table A4.9 Annual average activity concentrations in soil layers (Bq kg^{-1}) in 60^{th} year of operation for expected discharges to atmosphere from SZC at proposed limits$^{@}$ - Generic location 250 m north of north stack.

Soil layers (m)	Co-58	Co-60	Cs-134	Cs-137	Ba-137m*	Ba-137m (Cs-137)#	I-131	Xe-131m*	I-133	Xe-133*	Cs-135 (Xe-135)#
0 - 0.01	1.8 10^{-3}	2.2 10^{-2}	1.1 10^{-2}	2.2 10^{-2}	2.2 10^{-2}	8.3 10^{-9}	1.7 10^{-2}	1.7 10^{-2}	2.2 10^{-3}	2.2 10^{-3}	4.2 10^{-9}
0.01 - 0.05	3.1 10^{-5}	6.9 10^{-3}	1.7 10^{-3}	1.5 10^{-2}	1.5 10^{-2}	3.5 10^{-15}	3.3 10^{-5}	8.2 10^{-5}	4.7 10^{-7}	3.3 10^{-6}	3.9 10^{-9}
0.05 - 0.15	2.1 10^{-7}	1.0 10^{-3}	1.1 10^{-4}	5.7 10^{-3}	5.7 10^{-3}	6.2 10^{-22}	2.7 10^{-8}	1.2 10^{-7}	4.0 10^{-11}	1.7 10^{-9}	2.0 10^{-9}
0.15 - 0.3	1.5 10^{-9}	1.8 10^{-4}	8.4 10^{-6}	2.6 10^{-3}	2.6 10^{-3}	1.1 10^{-28}	2.2 10^{-11}	1.7 10^{-10}	3.6 10^{-15}	9.5 10^{-13}	1.1 10^{-9}
0.3 - 1	1.3 10^{-12}	4.0 10^{-6}	7.4 10^{-8}	1.3 10^{-4}	1.3 10^{-4}	2.4 10^{-36}	2.1 10^{-15}	2.6 10^{-14}	3.7 10^{-20}	5.8 10^{-17}	6.2 10^{-11}

Table A4.10 Annual average activity concentrations in soil layers (Bq kg^{-1}) in 60^{th} year of operation for expected discharges to atmosphere from SZC at proposed limits$^{@}$ - Generic location 500 m north of north stack.

Soil layers (m)	Co-58	Co-60	Cs-134	Cs-137	Ba-137m*	Ba-137m (Cs-137)#	I-131	Xe-131m*	I-133	Xe-133*	Cs-135 (Xe-135)#
0 - 0.01	1.1 10^{-3}	1.3 10^{-2}	6.4 10^{-3}	1.2 10^{-2}	1.2 10^{-2}	7.9 10^{-9}	1.0 10^{-2}	1.0 10^{-2}	1.3 10^{-3}	1.3 10^{-3}	4.4 10^{-9}
0.01 - 0.05	1.8 10^{-5}	3.9 10^{-3}	9.7 10^{-4}	8.7 10^{-3}	8.7 10^{-3}	3.4 10^{-15}	1.9 10^{-5}	4.8 10^{-5}	2.7 10^{-7}	1.9 10^{-6}	4.1 10^{-9}

Soil layers (m)	Co-58	Co-60	Cs-134	Cs-137	Ba-137m*	Ba-137m (Cs-137)#	I-131	Xe-131m*	I-133	Xe-133*	Cs-135 (Xe-135)#
0.05 - 0.15	1.2 10^{-7}	5.8 10^{-4}	6.5 10^{-5}	3.2 10^{-3}	3.2 10^{-3}	5.9 10^{-22}	1.5 10^{-8}	7.2 10^{-8}	2.3 10^{-11}	1.0 10^{-9}	2.1 10^{-9}
0.15 - 0.3	8.9 10^{-10}	1.0 10^{-4}	4.8 10^{-6}	1.5 10^{-3}	1.5 10^{-3}	1.1 10^{-28}	1.3 10^{-11}	1.0 10^{-10}	2.1 10^{-15}	5.5 10^{-13}	1.2 10^{-9}
0.3 - 1	7.4 10^{-13}	2.3 10^{-6}	4.3 10^{-8}	7.2 10^{-5}	7.2 10^{-5}	2.3 10^{-36}	1.2 10^{-15}	1.5 10^{-14}	2.1 10^{-20}	3.4 10^{-17}	6.5 10^{-11}

@ Deposition of C-14 and H-3 is not modelled and noble gases do not deposit.

* Ingrowth after deposition of parent

Ingrowth in plume

Table A4.11 Activity concentrations (Bq kg^{-1}) in terrestrial foods at allotment and salt marsh production locations in 60th year of operation for expected discharges to atmosphere from SZC at proposed limits.

Food	C-14 *	H-3 *	Co-58	Co-60	Cs-134	Cs-137	Ba-137m (Cs-137)	I-131	I-133	Cs-135 (Xe-135)
Green vegetables#	1.7 10^{0}	1.4 10^{0}	1.2 10^{-5}	1.8 10^{-5}	1.6 10^{-5}	1.7 10^{-5}	1.2 10^{-9}	3.7 10^{-4}	6.8 10^{-5}	3.1 10^{-11}
Fruit - Domestic#	1.7 10^{0}	1.4 10^{0}	2.0 10^{-6}	3.8 10^{-6}	4.1 10^{-5}	4.1 10^{-5}	8.5 10^{-11}	2.6 10^{-4}	6.5 10^{-6}	6.7 10^{-11}
Root vegetables#	1.7 10^{0}	1.4 10^{0}	3.4 10^{-8}	7.7 10^{-7}	1.4 10^{-5}	1.4 10^{-5}	1.4 10^{-13}	7.7 10^{-5}	5.2 10^{-7}	2.5 10^{-11}
Cow meat@	1.5 10^{1}	7.1 10^{0}	5.5 10^{-5}	2.8 10^{-4}	5.8 10^{-4}	6.1 10^{-4}	2.1 10^{-16}	1.4 10^{-3}	7.5 10^{-5}	4.3 10^{-10}
Cow liver@	1.5 10^{1}	7.1 10^{0}	5.5 10^{-5}	2.8 10^{-4}	5.8 10^{-4}	6.1 10^{-4}	2.1 10^{-16}	1.4 10^{-3}	7.5 10^{-5}	4.3 10^{-10}
Sheep meat@	1.5 10^{1}	7.1 10^{0}	9.6 10^{-7}	4.1 10^{-6}	1.1 10^{-3}	1.3 10^{-3}	2.5 10^{-16}	1.8 10^{-3}	4.6 10^{-5}	9.2 10^{-10}
Sheep liver@	1.5 10^{1}	7.1 10^{0}	9.6 10^{-5}	4.1 10^{-4}	1.1 10^{-3}	1.3 10^{-3}	2.5 10^{-16}	1.8 10^{-3}	4.6 10^{-5}	9.2 10^{-10}

* These radionuclides are modelled using specific activity approach.

Location = allotments

@ Location = salt marshes

Table A4.12 Activity concentrations (Bq kg^{-1}) in foods not included in PC-CREAM 08 at allotment and salt marsh production locations in 60th year of operation for expected discharges to atmosphere from SZC at proposed limits

Radionuclide	C-14	Co-58	Co-60	Cs-134	Cs-137	H-3	I-131	I-133
Eggs#	$2.5\ 10^{0}$	$2.2\ 10^{-8}$	$3.5\ 10^{-8}$	$2.3\ 10^{-6}$	$2.2\ 10^{-6}$	$1.2\ 10^{0}$	$9.1\ 10^{-5}$	$1.4\ 10^{-6}$
Meat – Pig@	$1.5\ 10^{1}$	$8.3\ 10^{-6}$	$1.3\ 10^{-5}$	$7.1\ 10^{-5}$	$6.9\ 10^{-5}$	$7.1\ 10^{0}$	$9.8\ 10^{-5}$	$1.5\ 10^{-6}$
Meat – Poultry#	$2.5\ 10^{0}$	$2.0\ 10^{-6}$	$3.1\ 10^{-6}$	$4.8\ 10^{-5}$	$4.6\ 10^{-5}$	$1.2\ 10^{0}$	$1.0\ 10^{-6}$	$1.6\ 10^{-8}$
Honey#	$6.3\ 10^{0}$	-	-	$2.6\ 10^{-4}$	$2.5\ 10^{-3}$	$3.4\ 10^{-1}$	-	-
Game meat*	$6.6\ 10^{0}$	$2.6\ 10^{-6}$	$8.0\ 10^{-5}$	$4.6\ 10^{-4}$	$3.3\ 10^{-3}$	$3.1\ 10^{0}$	$5.1\ 10^{-5}$	$6.5\ 10^{-6}$
Wild fruit/nuts*	$4.4\ 10^{0}$	$4.7\ 10^{-5}$	$1.5\ 10^{-3}$	$4.6\ 10^{-4}$	$4.4\ 10^{-3}$	$3.5\ 10^{0}$	$2.1\ 10^{-3}$	$2.8\ 10^{-4}$
Fungi*	$2.2\ 10^{0}$	$1.3\ 10^{-3}$	$4.1\ 10^{-2}$	$1.3\ 10^{-2}$	$1.2\ 10^{-1}$	$4.0\ 10^{0}$	$6.0\ 10^{-2}$	$7.6\ 10^{-3}$

Location = allotments

@ Location = salt marshes

* Location = open access land

Table A4.13 Activity concentrations (Bq kg^{-1}) in terrestrial foods at generic production location used in the generic assessment in 60th year of operation for expected discharges to atmosphere from SZC at proposed limits

Food	C-14 *	H-3 *	Co-58	Co-60	Cs-134	Cs-137	I-131	I-133
Green vegetables	2.7 10^{1}	2.2 10^{1}	1.7 10^{-4}	2.6 10^{-4}	2.3 10^{-4}	2.4 10^{-4}	6.3 10^{-3}	1.1 10^{-3}
Fruit	2.7 10^{1}	2.2 10^{1}	2.8 10^{-5}	5.5 10^{-5}	6.0 10^{-4}	5.7 10^{-4}	4.4 10^{-3}	1.1 10^{-4}
Root vegetables	2.7 10^{1}	2.2 10^{1}	4.9 10^{-7}	1.1 10^{-5}	2.1 10^{-4}	2.1 10^{-4}	1.3 10^{-3}	8.4 10^{-6}
Cow milk	1.3 10^{1}	2.4 10^{1}	4.9 10^{-6}	8.0 10^{-6}	2.8 10^{-4}	2.8 10^{-4}	8.9 10^{-3}	6.8 10^{-4}
Cow milk products	8.0 10^{1}	1.1 10^{1}	5.3 10^{-5}	8.8 10^{-5}	3.1 10^{-3}	3.1 10^{-3}	8.9 10^{-2}	3.4 10^{-3}
Cow meat	4.0 10^{1}	1.9 10^{1}	1.3 10^{-6}	6.6 10^{-6}	1.4 10^{-3}	1.4 10^{-3}	2.9 10^{-3}	1.8 10^{-5}
Cow liver	4.0 10^{1}	1.9 10^{1}	1.3 10^{-4}	6.6 10^{-4}	1.4 10^{-3}	1.4 10^{-3}	3.8 10^{-3}	2.0 10^{-4}
Sheep meat	4.0 10^{1}	1.9 10^{1}	2.1 10^{-6}	9.7 10^{-6}	2.7 10^{-3}	3.0 10^{-3}	2.6 10^{-3}	4.6 10^{-7}
Sheep liver	4.0 10^{1}	1.9 10^{1}	2.2 10^{-4}	9.8 10^{-4}	2.7 10^{-3}	3.0 10^{-3}	4.8 10^{-3}	1.2 10^{-4}

Table A4.14 Activity concentrations in local marine compartment in 60th year of operation for expected liquid discharges from SZC at proposed limits

Radionuclide	Ag-110m	C-14	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H-3	I-131	Xe-131m *
Filtered water (Bq l^{-1})	6.6 10^{-5}	1.3 10^{-2}	1.6 10^{-5}	3.4 10^{-5}	1.1 10^{-6}	6.4 10^{-5}	1.2 10^{-4}	1.4 10^{1}	1.3 10^{-6}	9.6 10^{-7}
Unfiltered water (Bq l^{-1})	6.9 10^{-5}	1.4 10^{-2}	1.3 10^{-4}	2.8 10^{-4}	3.0 10^{-6}	7.1 10^{-5}	1.3 10^{-4}	1.4 10^{1}	1.3 10^{-6}	9.6 10^{-7}
Bed sediment (Bq kg^{-1})	4.1 10^{-3}	2.4 10^{1}	5.4 10^{-2}	2.1 10^{0}	3.5 10^{-4}	3.0 10^{-2}	2.6 10^{-1}	2.5 10^{1}	2.9 10^{-7}	4.0 10^{-7}
Fish (Bq kg^{-1})	3.3 10^{-2}	2.5 10^{2}	1.6 10^{-2}	3.4 10^{-2}	2.1 10^{-4}	6.4 10^{-3}	1.2 10^{-2}	1.4 10^{1}	1.3 10^{-5}	0.0 10^{0}

Radionuclide	Ag-110m	C-14	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H-3	I-131	Xe-131m *
Crustaceans (Bq kg^{-1})	3.3 10^{-1}	2.5 10^{2}	1.6 10^{-1}	3.4 10^{-1}	5.3 10^{-4}	1.9 10^{-3}	3.6 10^{-3}	1.4 10^{1}	1.3 10^{-5}	0.0 10^{0}
Molluscs (Bq kg^{-1})	6.6 10^{-1}	2.5 10^{2}	8.0 10^{-2}	1.7 10^{-1}	8.5 10^{-4}	1.9 10^{-3}	3.6 10^{-3}	1.4 10^{1}	1.3 10^{-5}	0.0 10^{0}
Seaweed (Bq kg^{-1})	1.3 10^{-1}	1.3 10^{2}	1.6 10^{-1}	3.4 10^{-1}	2.1 10^{-3}	3.2 10^{-3}	6.0 10^{-3}	1.4 10^{1}	1.3 10^{-3}	0.0 10^{0}

Table A4.14 continued

Radionuclide	Mn-54	Ni-63	Sb-124	Sb-125	Te-125m *	Te-123m	Te-123 *
Filtered water (Bq l^{-1})	2.6 10^{-6}	2.5 10^{-5}	4.1 10^{-5}	1.1 10^{-4}	4.1 10^{-5}	2.7 10^{-5}	2.9 10^{-19}
Unfiltered water (Bq l^{-1})	2.2 10^{-5}	1.2 10^{-4}	4.2 10^{-5}	1.1 10^{-4}	4.2 10^{-5}	2.8 10^{-5}	3.0 10^{-19}
Bed sediment (Bq kg^{-1})	3.6 10^{-2}	2.1 10^{0}	6.4 10^{-4}	2.2 10^{-2}	2.2 10^{-2}	8.1 10^{-4}	1.1 10^{-15}
Fish (Bq kg^{-1})	1.0 10^{-3}	2.5 10^{-2}	1.6 10^{-2}	4.2 10^{-2}	4.1 10^{-2}	2.7 10^{-2}	2.9 10^{-16}
Crustaceans (Bq kg^{-1})	1.3 10^{-3}	2.5 10^{-2}	1.0 10^{-3}	2.6 10^{-3}	4.1 10^{-2}	2.7 10^{-2}	2.9 10^{-16}
Molluscs (Bq kg^{-1})	1.3 10^{-1}	5.0 10^{-2}	8.2 10^{-4}	2.1 10^{-3}	4.1 10^{-2}	2.7 10^{-2}	2.9 10^{-16}
Seaweed (Bq kg^{-1})	1.6 10^{-2}	5.0 10^{-2}	8.2 10^{-4}	2.1 10^{-3}	4.1 10^{-1}	2.7 10^{-1}	2.9 10^{-15}

* Progeny of preceding radionuclide in the table

Table A4.15 Activity concentrations in the North Sea South West regional compartment in 60^{th} year of operation for expected liquid discharges from SZC at proposed limits

Radionuclide	Ag-110m	C-14	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H-3	I-131	Xe-131m *
Filtered water (Bq l^{-1})	6.5 10^{-7}	2.0 10^{-4}	1.2 10^{-7}	4.2 10^{-7}	4.6 10^{-9}	7.9 10^{-7}	1.8 10^{-6}	2.1 10^{-1}	1.2 10^{-9}	2.3 10^{-9}
Unfiltered water (Bq l^{-1})	6.5 10^{-7}	2.0 10^{-4}	2.7 10^{-7}	9.3 10^{-7}	6.1 10^{-9}	8.1 10^{-7}	1.9 10^{-6}	2.1 10^{-1}	1.2 10^{-9}	2.3 10^{-9}

Radionuclide	Ag-110m	C-14	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H-3	I-131	Xe-131m *
Bed sediment (Bq kg^{-1})	3.5 10^{-5}	3.6 10^{-1}	3.5 10^{-4}	2.4 10^{-2}	1.3 10^{-6}	3.2 10^{-4}	3.7 10^{-3}	3.6 10^{-1}	2.6 10^{-10}	6.6 10^{-10}
Fish (Bq kg^{-1})	3.2 10^{-4}	4.0 10^{0}	1.2 10^{-4}	4.2 10^{-4}	9.3 10^{-7}	7.9 10^{-5}	1.8 10^{-4}	2.1 10^{-1}	1.2 10^{-8}	0.0 10^{0}
Crustaceans (Bq kg^{-1})	3.2 10^{-3}	4.0 10^{0}	1.2 10^{-3}	4.2 10^{-3}	2.3 10^{-6}	2.4 10^{-5}	5.5 10^{-5}	2.1 10^{-1}	1.2 10^{-8}	0.0 10^{0}
Molluscs (Bq kg^{-1})	6.5 10^{-3}	4.0 10^{0}	6.1 10^{-4}	2.1 10^{-3}	3.7 10^{-6}	2.4 10^{-5}	5.5 10^{-5}	2.1 10^{-1}	1.2 10^{-8}	0.0 10^{0}
Seaweed (Bq kg^{-1})	1.3 10^{-3}	2.0 10^{0}	1.2 10^{-3}	4.2 10^{-3}	9.3 10^{-6}	4.0 10^{-5}	9.1 10^{-5}	2.1 10^{-1}	1.2 10^{-6}	0.0 10^{0}

Table A4.15 continued

Radionuclide	Mn-54	Ni-63	Sb-124	Sb-125	Te-125m *	Te-123m	Te-123 *
Filtered water (Bq l^{-1})	2.5 10^{-8}	5.6 10^{-7}	2.0 10^{-7}	1.4 10^{-6}	1.1 10^{-6}	1.9 10^{-7}	1.1 10^{-20}
Unfiltered water (Bq l^{-1})	5.5 10^{-8}	8.9 10^{-7}	2.0 10^{-7}	1.4 10^{-6}	1.1 10^{-6}	2.0 10^{-7}	1.1 10^{-20}
Bed sediment (Bq kg^{-1})	3.0 10^{-4}	4.2 10^{-2}	2.7 10^{-6}	2.5 10^{-4}	2.6 10^{-4}	5.1 10^{-6}	1.6 10^{-17}
Fish (Bq kg^{-1})	1.0 10^{-5}	5.6 10^{-4}	8.1 10^{-5}	5.5 10^{-4}	1.1 10^{-3}	1.9 10^{-4}	1.1 10^{-17}
Crustaceans (Bq kg^{-1})	1.2 10^{-5}	5.6 10^{-4}	5.0 10^{-6}	3.4 10^{-5}	1.1 10^{-3}	1.9 10^{-4}	1.1 10^{-17}
Molluscs (Bq kg^{-1})	1.2 10^{-3}	1.1 10^{-3}	4.0 10^{-6}	2.7 10^{-5}	1.1 10^{-3}	1.9 10^{-4}	1.1 10^{-17}
Seaweed (Bq kg^{-1})	1.5 10^{-4}	1.1 10^{-3}	4.0 10^{-6}	2.7 10^{-5}	1.1 10^{-2}	1.9 10^{-3}	1.1 10^{-16}

* Progeny of preceding radionuclide in the table

Appendix 5 Doses to the Representative Person for SZC permitted discharges by pathway and radionuclide

The data presented here are annual effective doses in the 60th year of operation of SZC only. Doses are only presented for the most exposed group for each age category. No doses were calculated to Child Mollusc Consumers or Infant Sea Fish Consumers from discharges to atmosphere because no relevant habit data were recorded for this group in (Garrod et al, 2016).

Table A5.1 Annual dose (µSv) to Adult Sea Fish Consumers from discharges to atmosphere in the 60th year of operation of SZC. Plume IN, Plume MID and Plume OUT include doses from inhalation, external beta and gamma exposure to the plume and the ground, and resuspension.

Radionuclide / Pathway	Ar-41	C-14	Co-58	Co-60	Cs-134	Cs-137	H-3
Eggs	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Fruit - Domestic	$0.0\ 10^{0}$	$2.0\ 10^{-3}$	$2.8\ 10^{-9}$	$2.6\ 10^{-8}$	$1.6\ 10^{-6}$	$1.0\ 10^{-6}$	$4.9\ 10^{-5}$
Fruit and Nuts - Wild	$0.0\ 10^{0}$	$1.5\ 10^{-4}$	$2.1\ 10^{-9}$	$3.0\ 10^{-7}$	$5.2\ 10^{-7}$	$3.5\ 10^{-6}$	$3.8\ 10^{-6}$
Honey	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Cow	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Game	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Pig	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Poultry	$0.0\ 10^{0}$	$4.3\ 10^{-4}$	$4.3\ 10^{-10}$	$3.1\ 10^{-9}$	$2.7\ 10^{-7}$	$1.8\ 10^{-7}$	$6.2\ 10^{-6}$
Meat – Sheep	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Mushrooms	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Plume IN (0 to 0.25km)	$1.5\ 10^{-3}$	$3.2\ 10^{-2}$	$1.1\ 10^{-5}$	$5.1\ 10^{-4}$	$1.3\ 10^{-4}$	$2.1\ 10^{-4}$	$1.8\ 10^{-3}$
Plume MID (>0.25 to 0.5km)	$4.7\ 10^{-5}$	$3.1\ 10^{-3}$	$3.5\ 10^{-7}$	$1.5\ 10^{-5}$	$3.8\ 10^{-6}$	$6.2\ 10^{-6}$	$1.8\ 10^{-4}$
Plume OUT (>0.5 to 1km)	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$

Radionuclide / Pathway	Ar-41	C-14	Co-58	Co-60	Cs-134	Cs-137	H-3
Vegetables – Green	$0.0\ 10^{0}$	$3.8\ 10^{-3}$	$3.4\ 10^{-8}$	$2.3\ 10^{-7}$	$1.2\ 10^{-6}$	$8.2\ 10^{-7}$	$9.5\ 10^{-5}$
Vegetables – Other Domestic	$0.0\ 10^{0}$	$2.6\ 10^{-3}$	$2.4\ 10^{-8}$	$1.6\ 10^{-7}$	$8.0\ 10^{-7}$	$5.7\ 10^{-7}$	$6.6\ 10^{-5}$
Vegetables – Potatoes	$0.0\ 10^{0}$	$7.0\ 10^{-3}$	$1.8\ 10^{-10}$	$1.9\ 10^{-8}$	$1.9\ 10^{-6}$	$1.3\ 10^{-6}$	$1.8\ 10^{-4}$
Vegetables – Root	$0.0\ 10^{0}$	$3.7\ 10^{-3}$	$9.3\ 10^{-11}$	$1.0\ 10^{-8}$	$1.0\ 10^{-6}$	$7.1\ 10^{-7}$	$9.3\ 10^{-5}$
Total	$1.6\ 10^{-3}$	$5.5\ 10^{-2}$	$1.1\ 10^{-5}$	$5.3\ 10^{-4}$	$1.4\ 10^{-4}$	$2.2\ 10^{-4}$	$2.5\ 10^{-3}$

Table 5.1 continued

Radionuclide / Pathway	I-131	I-133	Kr-85	Xe-131m	Xe-133	Xe-135	Total
Eggs	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Fruit – Domestic	$1.2\ 10^{-5}$	$5.4\ 10^{-8}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.7\ 10^{-13}$	$2.0\ 10^{-3}$
Fruit and Nuts - Wild	$2.8\ 10^{-6}$	$7.1\ 10^{-8}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$9.1\ 10^{-13}$	$1.6\ 10^{-4}$
Honey	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Cow	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Game	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Pig	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Poultry	$6.7\ 10^{-9}$	$1.9\ 10^{-11}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.9\ 10^{-14}$	$4.3\ 10^{-4}$
Meat – Sheep	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Mushrooms	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Plume IN (0 to 0.25km)	$8.4\ 10^{-5}$	$2.0\ 10^{-5}$	$5.0\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.3\ 10^{-3}$	$3.8\ 10^{-2}$
Plume MID (>0.25 to 0.5km)	$4.6\ 10^{-6}$	$1.1\ 10^{-6}$	$4.1\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$7.5\ 10^{-5}$	$3.5\ 10^{-3}$
Plume OUT (>0.5 to 1km)	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Vegetables – Green	$3.2\ 10^{-5}$	$1.1\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.4\ 10^{-13}$	$3.9\ 10^{-3}$
Vegetables – Other Domestic	$2.2\ 10^{-5}$	$7.7\ 10^{-7}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.6\ 10^{-13}$	$2.7\ 10^{-3}$
Vegetables – Potatoes	$1.2\ 10^{-5}$	$1.5\ 10^{-8}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.8\ 10^{-13}$	$7.2\ 10^{-3}$
Vegetables – Root	$6.5\ 10^{-6}$	$8.1\ 10^{-9}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.0\ 10^{-13}$	$3.8\ 10^{-3}$
Total	$1.8\ 10^{-4}$	$2.3\ 10^{-5}$	$5.4\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.3\ 10^{-3}$	$6.2\ 10^{-2}$

Table A5.2 Annual dose (µSv) to Adult Sea Fish Consumers from liquid releases in 60th year of operation of SZC

Radionuclide / Pathway	Ag-110m	C-14	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H-3
Crustacea	$6.6\ 10^{-4}$	$1.0\ 10^{-1}$	$8.4\ 10^{-5}$	$8.2\ 10^{-4}$	$1.4\ 10^{-8}$	$2.6\ 10^{-5}$	$3.3\ 10^{-5}$	$1.8\ 10^{-4}$
Fish - Sea	$2.2\ 10^{-3}$	$3.5\ 10^{0}$	$2.8\ 10^{-4}$	$2.7\ 10^{-3}$	$1.9\ 10^{-7}$	$2.9\ 10^{-3}$	$3.7\ 10^{-3}$	$6.1\ 10^{-3}$
Gamma external – Houseboat	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Gamma external – Salt marsh	$2.4\ 10^{-5}$	$3.8\ 10^{-6}$	$1.1\ 10^{-4}$	$1.1\ 10^{-2}$	$2.4\ 10^{-8}$	$9.7\ 10^{-5}$	$3.2\ 10^{-4}$	$0.0\ 10^{0}$
Gamma external – Sediments	$1.9\ 10^{-4}$	$2.2\ 10^{-4}$	$8.5\ 10^{-4}$	$8.8\ 10^{-2}$	$1.9\ 10^{-7}$	$7.6\ 10^{-4}$	$2.5\ 10^{-3}$	$0.0\ 10^{0}$
Marine plants/algae	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat - Wildfowl	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Mollusca	$1.7\ 10^{-4}$	$1.3\ 10^{-2}$	$5.3\ 10^{-6}$	$5.2\ 10^{-5}$	$2.9\ 10^{-9}$	$3.3\ 10^{-6}$	$4.2\ 10^{-6}$	$2.3\ 10^{-5}$
Occupancy IN water	$6.6\ 10^{-14}$	$1.4\ 10^{-16}$	$4.4\ 10^{-14}$	$2.6\ 10^{-13}$	$3.0\ 10^{-17}$	$3.7\ 10^{-14}$	$2.5\ 10^{-14}$	$3.2\ 10^{-19}$
Occupancy ON water	$8.9\ 10^{-12}$	$1.9\ 10^{-14}$	$6.0\ 10^{-12}$	$3.5\ 10^{-11}$	$4.0\ 10^{-15}$	$5.0\ 10^{-12}$	$3.4\ 10^{-12}$	$4.3\ 10^{-17}$
Total	$3.2\ 10^{-3}$	3.6 E+00	$1.3\ 10^{-3}$	$1.0\ 10^{-1}$	$4.2\ 10^{-7}$	$3.8\ 10^{-3}$	$6.6\ 10^{-3}$	$6.3\ 10^{-3}$

Table A5.2 continued

Radionuclide / Pathway	I-131	Mn-54	Ni-63	Sb-124	Sb-125	Te-123m	Total
Crustacea	$2.0\ 10^{-7}$	$6.6\ 10^{-7}$	$2.6\ 10^{-6}$	$1.8\ 10^{-6}$	$2.7\ 10^{-5}$	$2.6\ 10^{-5}$	$1.1\ 10^{-1}$
Fish – Sea	$6.6\ 10^{-6}$	$1.7\ 10^{-5}$	$8.7\ 10^{-5}$	$9.6\ 10^{-4}$	$1.9\ 10^{-3}$	$8.7\ 10^{-4}$	$3.5\ 10^{0}$
Gamma external – Houseboat	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Gamma external – Salt marsh	$2.5\ 10^{-10}$	$6.3\ 10^{-5}$	$0.0\ 10^{0}$	$2.4\ 10^{-6}$	$2.1\ 10^{-5}$	$2.5\ 10^{-7}$	$1.2\ 10^{-2}$
Gamma external – Sediments	$2.0\ 10^{-9}$	$5.0\ 10^{-4}$	$0.0\ 10^{0}$	$1.9\ 10^{-5}$	$1.7\ 10^{-4}$	$2.0\ 10^{-6}$	$9.3\ 10^{-2}$
Marine plants/algae	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Wildfowl	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Mollusca	$2.5\ 10^{-8}$	$8.3\ 10^{-6}$	$6.7\ 10^{-7}$	$1.8\ 10^{-7}$	$3.4\ 10^{-6}$	$3.3\ 10^{-6}$	$1.4\ 10^{-2}$
Occupancy IN water	$1.6\ 10^{-16}$	$6.2\ 10^{-15}$	$3.2\ 10^{-21}$	$2.8\ 10^{-14}$	$1.5\ 10^{-14}$	$1.1\ 10^{-15}$	$4.8\ 10^{-13}$
Occupancy ON water	$2.1\ 10^{-14}$	$8.4\ 10^{-13}$	$4.4\ 10^{-19}$	$3.8\ 10^{-12}$	$2.0\ 10^{-12}$	$1.5\ 10^{-13}$	$6.5\ 10^{-11}$
Total	$6.8\ 10^{-6}$	$5.8\ 10^{-4}$	$9.1\ 10^{-5}$	$9.9\ 10^{-4}$	$2.1\ 10^{-3}$	$9.1\ 10^{-4}$	$3.7\ 10^{0}$

Table A5.3 Annual dose (µSv) to Child Mollusc Consumers from liquid releases in 60th year of operation of SZC

Radionuclide / Pathway	Ag-110m	C-14	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H-3
Crustacea	$4.0\ 10^{-4}$	$4.7\ 10^{-2}$	$6.3\ 10^{-5}$	$8.6\ 10^{-4}$	$9.6\ 10^{-9}$	$6.2\ 10^{-6}$	$8.3\ 10^{-6}$	$7.6\ 10^{-5}$
Fish – Sea	$2.9\ 10^{-3}$	$3.5\ 10^{0}$	$4.6\ 10^{-4}$	$6.4\ 10^{-3}$	$2.8\ 10^{-7}$	$1.5\ 10^{-3}$	$2.0\ 10^{-3}$	$5.6\ 10^{-3}$
Gamma external – Houseboat	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Gamma external – Salt marsh	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Gamma external – Sediments	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Marine plants/algae	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Wildfowl	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Mollusca	$2.7\ 10^{-3}$	$1.6\ 10^{-1}$	$1.1\ 10^{-4}$	$1.5\ 10^{-3}$	$5.2\ 10^{-8}$	$2.1\ 10^{-5}$	$2.8\ 10^{-5}$	$2.6\ 10^{-4}$
Occupancy IN water	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Occupancy ON water	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Total	$6.1\ 10^{-3}$	$3.7\ 10^{0}$	$6.3\ 10^{-4}$	$8.7\ 10^{-3}$	$3.4\ 10^{-7}$	$1.6\ 10^{-3}$	$2.1\ 10^{-3}$	$5.9\ 10^{-3}$

Table A5.3 continued

Radionuclide / Pathway	I-131	Mn-54	Ni-63	Sb-124	Sb-125	Te-123m	Total
Crustacea	$1.5\ 10^{-7}$	$3.9\ 10^{-7}$	$1.6\ 10^{-6}$	$1.2\ 10^{-6}$	$1.9\ 10^{-5}$	$1.7\ 10^{-5}$	$4.8\ 10^{-2}$
Fish - Sea	$1.1\ 10^{-5}$	$2.3\ 10^{-5}$	$1.2\ 10^{-4}$	$1.4\ 10^{-3}$	$2.8\ 10^{-3}$	$1.3\ 10^{-3}$	$3.5\ 10^{0}$
Gamma external - Houseboat	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Gamma external - Salt marsh	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Gamma external - Sediments	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Marine plants/algae	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat - Wildfowl	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Mollusca	$5.2\ 10^{-7}$	$1.3\ 10^{-4}$	$1.1\ 10^{-5}$	$3.4\ 10^{-6}$	$6.5\ 10^{-5}$	$5.9\ 10^{-5}$	$1.7\ 10^{-1}$
Occupancy IN water	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Occupancy ON water	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Total	$1.2\ 10^{-5}$	$1.6\ 10^{-4}$	$1.3\ 10^{-4}$	$1.5\ 10^{-3}$	$2.9\ 10^{-3}$	$1.3\ 10^{-3}$	$3.7\ 10^{0}$

Table A5.4 Annual dose (µSv) to Infant Sea Fish Consumers from liquid releases in 60th year of operation of SZC

Radionuclide / Pathway	Ag-110m	C-14	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H-3
Crustacea	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Fish - Sea	$3.4\ 10^{-3}$	$3.0\ 10^{0}$	$5.2\ 10^{-4}$	$6.8\ 10^{-3}$	$3.6\ 10^{-7}$	$7.6\ 10^{-4}$	$1.1\ 10^{-3}$	$5.1\ 10^{-3}$
Gamma external - Houseboat	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Gamma external - Salt marsh	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Gamma external - Sediments	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Marine plants/algae	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat - Wildfowl	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$

Radionuclide / Pathway	Ag-110m	C-14	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H-3
Mollusca	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Occupancy IN water	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Occupancy ON water	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Total	$3.4\ 10^{-3}$	$3.0\ 10^{0}$	$5.2\ 10^{-4}$	$6.8\ 10^{-3}$	$3.6\ 10^{-7}$	$7.6\ 10^{-4}$	$1.1\ 10^{-3}$	$5.1\ 10^{-3}$

Table A5.4 continued

Radionuclide / Pathway	I-131	Mn-54	Ni-63	Sb-124	Sb-125	Te-123m	Total
Crustacea	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Fish - Sea	$1.7\ 10^{-5}$	$2.4\ 10^{-5}$	$1.5\ 10^{-4}$	$1.9\ 10^{-3}$	$3.8\ 10^{-3}$	$1.7\ 10^{-3}$	$3.0\ 10^{0}$
Gamma external – Houseboat	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Gamma external – Salt marsh	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Gamma external – Sediments	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Marine plants/algae	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Wildfowl	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Mollusca	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Occupancy IN water	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Occupancy ON water	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Total	$1.7\ 10^{-5}$	$2.4\ 10^{-5}$	$1.5\ 10^{-4}$	$1.9\ 10^{-3}$	$3.8\ 10^{-3}$	$1.7\ 10^{-3}$	$3.0\ 10^{0}$

Table A5.5 Annual dose (µSv) to Adult members of the Plume IN group from discharges to atmosphere in the 60th year of operation of SZC. Plume IN, Plume MID and Plume OUT include doses from inhalation, external beta and gamma exposure to the plume and the ground, and resuspension.

Radionuclide / Pathway	Ar-41	C-14	Co-58	Co-60	Cs-134	Cs-137	H-3
Eggs	$0.0\ 10^{0}$	$1.8\ 10^{-2}$	$2.0\ 10^{-10}$	$1.4\ 10^{-9}$	$5.4\ 10^{-7}$	$3.5\ 10^{-7}$	$2.6\ 10^{-4}$
Fruit – Domestic	$0.0\ 10^{0}$	$4.1\ 10^{-3}$	$6.0\ 10^{-9}$	$5.4\ 10^{-8}$	$3.3\ 10^{-6}$	$2.1\ 10^{-6}$	$1.0\ 10^{-4}$
Fruit and Nuts – Wild	$0.0\ 10^{0}$	$5.1\ 10^{-3}$	$6.9\ 10^{-8}$	$1.0\ 10^{-5}$	$1.7\ 10^{-5}$	$1.2\ 10^{-4}$	$1.3\ 10^{-4}$
Honey	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Cow	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Game	$0.0\ 10^{0}$	$1.9\ 10^{-4}$	$9.8\ 10^{-11}$	$1.4\ 10^{-8}$	$4.4\ 10^{-7}$	$2.2\ 10^{-6}$	$2.8\ 10^{-6}$
Meat – Pig	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Poultry	$0.0\ 10^{0}$	$5.9\ 10^{-4}$	$6.0\ 10^{-10}$	$4.3\ 10^{-9}$	$3.7\ 10^{-7}$	$2.4\ 10^{-7}$	$8.5\ 10^{-6}$
Meat – Sheep	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Mushrooms	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Plume IN (0 to 0.25km)	$5.5\ 10^{-2}$	$1.1\ 10^{0}$	$3.8\ 10^{-4}$	$1.8\ 10^{-2}$	$4.6\ 10^{-3}$	$7.6\ 10^{-3}$	$6.6\ 10^{-2}$
Plume MID (>0.25 to 0.5km)	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Plume OUT (>0.5 to 1km)	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Vegetables – Green	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Vegetables – Other Domestic	$0.0\ 10^{0}$	$2.1\ 10^{-3}$	$1.8\ 10^{-8}$	$1.3\ 10^{-7}$	$6.3\ 10^{-7}$	$4.4\ 10^{-7}$	$5.1\ 10^{-5}$
Vegetables – Potatoes	$0.0\ 10^{0}$	$4.7\ 10^{-3}$	$1.2\ 10^{-10}$	$1.3\ 10^{-8}$	$1.3\ 10^{-6}$	$8.9\ 10^{-7}$	$1.2\ 10^{-4}$
Vegetables – Root	$0.0\ 10^{0}$	$3.9\ 10^{-3}$	$9.8\ 10^{-11}$	$1.1\ 10^{-8}$	$1.1\ 10^{-6}$	$7.4\ 10^{-7}$	$9.8\ 10^{-5}$
Total	$5.5\ 10^{-2}$	$1.2\ 10^{0}$	$3.8\ 10^{-4}$	$1.8\ 10^{-2}$	$4.6\ 10^{-3}$	$7.7\ 10^{-3}$	$6.7\ 10^{-2}$

Table A5.5 continued

Radionuclide / Pathway	I-131	I-133	Kr-85	Xe-131m	Xe-133	Xe-135	Total
Eggs	$2.4\ 10^{-5}$	$7.1\ 10^{-8}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$9.6\ 10^{-14}$	$1.8\ 10^{-2}$
Fruit – Domestic	$2.4\ 10^{-5}$	$1.1\ 10^{-7}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$5.7\ 10^{-13}$	$4.2\ 10^{-3}$
Fruit and Nuts – Wild	$9.4\ 10^{-5}$	$2.4\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.0\ 10^{-11}$	$5.4\ 10^{-3}$
Honey	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Cow	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Game	$5.6\ 10^{-8}$	$1.4\ 10^{-9}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$5.0\ 10^{-13}$	$2.0\ 10^{-4}$
Meat – Pig	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Poultry	$9.2\ 10^{-9}$	$2.7\ 10^{-11}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.7\ 10^{-14}$	$6.0\ 10^{-4}$
Meat – Sheep	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Mushrooms	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Plume IN (0 to 0.25km)	$3.0\ 10^{-3}$	$7.1\ 10^{-4}$	$1.8\ 10^{-3}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$8.2\ 10^{-2}$	$1.4\ 10^{0}$
Plume MID (>0.25 to 0.5km)	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Plume OUT (>0.5 to 1km)	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Vegetables – Green	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Vegetables – Other Domestic	$1.7\ 10^{-5}$	$6.0\ 10^{-7}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.3\ 10^{-13}$	$2.1\ 10^{-3}$
Vegetables – Potatoes	$8.2\ 10^{-6}$	$1.0\ 10^{-8}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.5\ 10^{-13}$	$4.8\ 10^{-3}$
Vegetables – Root	$6.8\ 10^{-6}$	$8.6\ 10^{-9}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.1\ 10^{-13}$	$4.0\ 10^{-3}$
Total	$3.2\ 10^{-3}$	$7.1\ 10^{-4}$	$1.8\ 10^{-3}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$8.2\ 10^{-2}$	$1.4\ 10^{0}$

Table A5.6 Annual dose (µSv) to Adult members of the Plume IN group from liquid releases in 60th year of operation of SZC

Radionuclide / Pathway	Ag-110m	C-14	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H-3
Crustacea	$1.4\ 10^{-4}$	$2.2\ 10^{-2}$	$1.8\ 10^{-5}$	$1.7\ 10^{-4}$	$3.0\ 10^{-9}$	$5.5\ 10^{-6}$	$7.0\ 10^{-6}$	$3.9\ 10^{-5}$
Fish - Sea	$7.3\ 10^{-4}$	$1.2\ 10^{0}$	$9.4\ 10^{-5}$	$9.1\ 10^{-4}$	$6.4\ 10^{-8}$	$9.6\ 10^{-4}$	$1.2\ 10^{-3}$	$2.0\ 10^{-3}$
Gamma external – Houseboat	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Gamma external – Salt marsh	$1.0\ 10^{-6}$	$1.6\ 10^{-7}$	$4.7\ 10^{-6}$	$4.8\ 10^{-4}$	$1.0\ 10^{-9}$	$4.2\ 10^{-6}$	$1.4\ 10^{-5}$	$0.0\ 10^{0}$
Gamma external – Sediments	$2.7\ 10^{-4}$	$3.1\ 10^{-4}$	$1.2\ 10^{-3}$	$1.3\ 10^{-1}$	$2.7\ 10^{-7}$	$1.1\ 10^{-3}$	$3.7\ 10^{-3}$	$0.0\ 10^{0}$
Marine plants/algae	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Wildfowl	$1.6\ 10^{-3}$	$5.0\ 10^{-3}$	$2.4\ 10^{-6}$	$2.3\ 10^{-5}$	$3.2\ 10^{-8}$	$2.3\ 10^{-4}$	$3.0\ 10^{-4}$	$1.0\ 10^{-4}$
Mollusca	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Occupancy IN water	$2.6\ 10^{-7}$	$5.5\ 10^{-10}$	$1.8\ 10^{-7}$	$1.0\ 10^{-6}$	$1.2\ 10^{-10}$	$1.5\ 10^{-7}$	$1.0\ 10^{-7}$	$1.3\ 10^{-12}$
Occupancy ON water	$5.3\ 10^{-6}$	$1.1\ 10^{-8}$	$3.6\ 10^{-6}$	$2.1\ 10^{-5}$	$2.4\ 10^{-9}$	$3.0\ 10^{-6}$	$2.0\ 10^{-6}$	$2.5\ 10^{-11}$
Total	$2.8\ 10^{-3}$	$1.2\ 10^{0}$	$1.4\ 10^{-3}$	$1.3\ 10^{-1}$	$3.7\ 10^{-7}$	$2.3\ 10^{-3}$	$5.2\ 10^{-3}$	$2.2\ 10^{-3}$

Table A5.6 continued

Radionuclide / Pathway	I-131	Mn-54	Ni-63	Sb-124	Sb-125	Te-123m	Total
Crustacea	$4.2\ 10^{-8}$	$1.4\ 10^{-7}$	$5.6\ 10^{-7}$	$3.8\ 10^{-7}$	$5.7\ 10^{-6}$	$5.6\ 10^{-6}$	$2.3\ 10^{-2}$
Fish – Sea	$2.2\ 10^{-6}$	$5.8\ 10^{-6}$	$2.9\ 10^{-5}$	$3.2\ 10^{-4}$	$6.4\ 10^{-4}$	$2.9\ 10^{-4}$	$1.2\ 10^{0}$
Gamma external – Houseboat	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Gamma external – Salt marsh	$1.1\ 10^{-11}$	$2.7\ 10^{-6}$	$0.0\ 10^{0}$	$1.0\ 10^{-7}$	$9.2\ 10^{-7}$	$1.1\ 10^{-8}$	$5.1\ 10^{-4}$
Gamma external – Sediments	$2.9\ 10^{-9}$	$7.2\ 10^{-4}$	$0.0\ 10^{0}$	$2.7\ 10^{-5}$	$2.4\ 10^{-4}$	$2.9\ 10^{-6}$	$1.3\ 10^{-1}$
Marine plants/algae	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Meat – Wildfowl	$7.6\ 10^{-9}$	$3.3\ 10^{-6}$	$7.4\ 10^{-7}$	$3.4\ 10^{-4}$	$5.0\ 10^{-4}$	$1.2\ 10^{-4}$	$8.3\ 10^{-3}$
Mollusca	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Occupancy IN water	$6.3\ 10^{-10}$	$2.5\ 10^{-8}$	$1.3\ 10^{-14}$	$1.1\ 10^{-7}$	$6.1\ 10^{-8}$	$4.3\ 10^{-9}$	$1.9\ 10^{-6}$
Occupancy ON water	$1.3\ 10^{-8}$	$5.0\ 10^{-7}$	$2.6\ 10^{-13}$	$2.3\ 10^{-6}$	$1.2\ 10^{-6}$	$8.6\ 10^{-8}$	$3.8\ 10^{-5}$
Total	$2.3\ 10^{-6}$	$7.3\ 10^{-4}$	$3.1\ 10^{-5}$	$6.9\ 10^{-4}$	$1.4\ 10^{-3}$	$4.3\ 10^{-4}$	$1.3\ 10^{0}$

Table A5.7 Annual dose (μSv) to Adult with generic habits from atmospheric releases in 60th year of operation of SZC* Plume at 250m includes doses from inhalation, external beta and gamma exposure to the plume and the ground, and resuspension.

Radionuclide / Pathway	Ar-41	C-14	Co-58	Co-60	Cs-134	Cs-137	H-3
Plume at 250m	$2.4\ 10^{-2}$	$1.4\ 10^{0}$	$1.3\ 10^{-4}$	$5.6\ 10^{-3}$	$1.5\ 10^{-3}$	$2.3\ 10^{-3}$	$8.0\ 10^{-2}$
Cow liver	$0.0\ 10^{0}$	$6.4\ 10^{-2}$	$2.7\ 10^{-7}$	$6.1\ 10^{-6}$	$7.2\ 10^{-5}$	$5.1\ 10^{-5}$	$9.4\ 10^{-4}$
Cow meat	$0.0\ 10^{0}$	$3.5\ 10^{-1}$	$1.4\ 10^{-8}$	$3.3\ 10^{-7}$	$3.9\ 10^{-4}$	$2.8\ 10^{-4}$	$5.1\ 10^{-3}$
Cow milk	$0.0\ 10^{0}$	$1.9\ 10^{0}$	$8.7\ 10^{-7}$	$6.5\ 10^{-6}$	$1.3\ 10^{-3}$	$8.7\ 10^{-4}$	$1.1\ 10^{-1}$
Cow milk products	$0.0\ 10^{0}$	$2.8\ 10^{0}$	$2.4\ 10^{-6}$	$1.8\ 10^{-5}$	$3.5\ 10^{-3}$	$2.4\ 10^{-3}$	$1.2\ 10^{-2}$

Radionuclide / Pathway	Ar-41	C-14	Co-58	Co-60	Cs-134	Cs-137	H-3
Fruit	0.0 10^{0}	3.1 10^{-1}	4.2 10^{-7}	3.8 10^{-6}	2.3 10^{-4}	1.5 10^{-4}	7.7 10^{-3}
Green vegetables	0.0 10^{0}	5.4 10^{-1}	4.5 10^{-6}	3.1 10^{-5}	1.5 10^{-4}	1.1 10^{-4}	1.4 10^{-2}
Root vegetables	0.0 10^{0}	9.3 10^{-1}	2.2 10^{-8}	2.3 10^{-6}	2.4 10^{-4}	1.6 10^{-4}	2.3 10^{-2}
Sheep liver	0.0 10^{0}	6.4 10^{-2}	4.5 10^{-7}	9.1 10^{-6}	1.4 10^{-4}	1.1 10^{-4}	9.4 10^{-4}
Sheep meat	0.0 10^{0}	1.9 10^{-1}	1.2 10^{-8}	2.6 10^{-7}	4.1 10^{-4}	3.1 10^{-4}	2.7 10^{-3}
Total	2.4 10^{-2}	8.5 10^{0}	1.4 10^{-4}	5.7 10^{-3}	7.8 10^{-3}	6.8 10^{-3}	2.5 10^{-1}

Table A5.7 continued

Radionuclide / Pathway	I-131	I-133	Kr-85	Xe-131m	Xe-133	Xe-135	Total
Plume at 250m	2.1 10^{-3}	5.2 10^{-4}	1.8 10^{-3}	2.8 10^{-5}	1.8 10^{-2}	3.6 10^{-2}	**1.6 10^{0}**
Cow liver	2.3 10^{-4}	2.4 10^{-6}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	**6.6 10^{-2}**
Cow meat	9.6 10^{-4}	1.2 10^{-6}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	**3.6 10^{-1}**
Cow milk	4.7 10^{-2}	7.1 10^{-4}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	**2.0 10^{0}**
Cow milk products	1.2 10^{-1}	8.7 10^{-4}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	**2.9 10^{0}**
Fruit	2.0 10^{-3}	9.2 10^{-6}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	**3.2 10^{-1}**
Green vegetables	4.8 10^{-3}	1.7 10^{-4}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	**5.6 10^{-1}**
Root vegetables	1.7 10^{-3}	2.2 10^{-6}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	**9.6 10^{-1}**
Sheep liver	2.9 10^{-4}	1.5 10^{-6}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	**6.6 10^{-2}**
Sheep meat	4.6 10^{-4}	1.6 10^{-8}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	**1.9 10^{-1}**
Total	**1.8 10^{-1}**	**2.3 10^{-3}**	**1.8 10^{-3}**	**2.8 10^{-5}**	**1.8 10^{-2}**	**3.6 10^{-2}**	**9.0 10^{0}**

* The generic adult is assumed to live 250m from release point and eat food produced 500m from release point.

Table A5.8 Annual dose (µSv) to Child with generic habits from atmospheric releases in 60th year of operation of SZC* Plume at 250m includes doses from inhalation, external beta and gamma exposure to the plume and the ground, and resuspension.

Radionuclide / Pathway	Ar-41	C-14	Co-58	Co-60	Cs-134	Cs-137	H-3
Plume at 250m	$2.4\ 10^{-2}$	$1.3\ 10^{0}$	$1.4\ 10^{-4}$	$5.6\ 10^{-3}$	$1.4\ 10^{-3}$	$2.3\ 10^{-3}$	$7.1\ 10^{-2}$
Cow liver	$0.0\ 10^{0}$	$4.8\ 10^{-2}$	$3.4\ 10^{-7}$	$1.1\ 10^{-5}$	$2.9\ 10^{-5}$	$2.2\ 10^{-5}$	$6.5\ 10^{-4}$
Cow meat	$0.0\ 10^{0}$	$4.8\ 10^{-1}$	3.3 10-8	$1.1\ 10^{-6}$	$2.9\ 10^{-4}$	$2.2\ 10^{-4}$	$6.5\ 10^{-3}$
Cow milk	$0.0\ 10^{0}$	$2.6\ 10^{0}$	$2.0\ 10^{-6}$	$2.1\ 10^{-5}$	$9.4\ 10^{-4}$	$6.7\ 10^{-4}$	$1.3\ 10^{-1}$
Cow milk products	$0.0\ 10^{0}$	$2.9\ 10^{0}$	$4.1\ 10^{-6}$	$4.3\ 10^{-5}$	$1.9\ 10^{-3}$	$1.4\ 10^{-3}$	$1.1\ 10^{-2}$
Fruit	$0.0\ 10^{0}$	$3.2\ 10^{-1}$	$7.2\ 10^{-7}$	$9.1\ 10^{-6}$	$1.3\ 10^{-4}$	$8.6\ 10^{-5}$	$7.4\ 10^{-3}$
Green vegetables	$0.0\ 10^{0}$	$3.2\ 10^{-1}$	$4.4\ 10^{-6}$	$4.3\ 10^{-5}$	$4.8\ 10^{-5}$	$3.6\ 10^{-5}$	$7.4\ 10^{-3}$
Root vegetables	$0.0\ 10^{0}$	$1.1\ 10^{0}$	$4.1\ 10^{-8}$	$6.3\ 10^{-6}$	$1.5\ 10^{-4}$	$1.1\ 10^{-4}$	$2.5\ 10^{-2}$
Sheep liver	$0.0\ 10^{0}$	$4.8\ 10^{-2}$	$5.6\ 10^{-7}$	$1.6\ 10^{-5}$	$5.7\ 10^{-5}$	$4.5\ 10^{-5}$	$6.5\ 10^{-4}$
Sheep meat	$0.0\ 10^{0}$	$1.3\ 10^{-1}$	$1.4\ 10^{-8}$	$4.3\ 10^{-7}$	$1.5\ 10^{-4}$	$1.2\ 10^{-4}$	$1.7\ 10^{-3}$
Total	**$2.4\ 10^{-2}$**	**$9.2\ 10^{0}$**	**$1.5\ 10^{-4}$**	**$5.8\ 10^{-3}$**	**$5.1\ 10^{-3}$**	**$5.0\ 10^{-3}$**	**$2.6\ 10^{-1}$**

Table A5.8 continued

Radionuclide / Pathway	I-131	I-133	Kr-85	Xe-131m	Xe-133	Xe-135	Total
Plume at 250m	$3.2\ 10^{-3}$	$7.8\ 10^{-4}$	$1.8\ 10^{-3}$	$2.8\ 10^{-5}$	$1.8\ 10^{-2}$	$3.6\ 10^{-2}$	**$1.5\ 10^{0}$**
Cow liver	$2.9\ 10^{-4}$	$3.0\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$4.9\ 10^{-2}$**
Cow meat	$2.3\ 10^{-3}$	$2.7\ 10^{-6}$	$0.0\ 10^{0}$	0.0 100	0.0 100	0.0 100	**$4.9\ 10^{-1}$**
Cow milk	$1.1\ 10^{-1}$	$1.6\ 10^{-3}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$2.8\ 10^{0}$**
Cow milk products	$2.1\ 10^{-1}$	$1.5\ 10^{-3}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$3.1\ 10^{0}$**
Fruit	$3.5\ 10^{-3}$	$1.6\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$3.3\ 10^{-1}$**
Green vegetables	$4.9\ 10^{-3}$	$1.7\ 10^{-4}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$3.3\ 10^{-1}$**
Root vegetables	$3.4\ 10^{-3}$	$4.2\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$1.1\ 10^{0}$**
Sheep liver	$3.8\ 10^{-4}$	$1.8\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$4.9\ 10^{-2}$**
Sheep meat	$5.5\ 10^{-4}$	$1.8\ 10^{-8}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$1.3\ 10^{-1}$**
Total	**$3.4\ 10^{-1}$**	**$4.1\ 10^{-3}$**	**$1.8\ 10^{-3}$**	**$2.8\ 10^{-5}$**	**$1.8\ 10^{-2}$**	**$3.6\ 10^{-2}$**	**$9.9\ 10^{0}$**

* The generic child is assumed to live 250m from release point and eat food produced 500m from release point

Table A5.9 Annual dose (µSv) to Infant with generic habits from atmospheric releases in 60^{th} year of operation of SZC* Plume at 250m includes doses from inhalation, external beta and gamma exposure to the plume and the ground, and resuspension.

Radionuclide / Pathway	Ar-41	C-14	Co-58	Co-60	Cs-134	Cs-137	H-3
Plume at 250m	$2.4\ 10^{-2}$	$1.1\ 10^{0}$	$1.3\ 10^{-4}$	$5.6\ 10^{-3}$	$1.4\ 10^{-3}$	$2.3\ 10^{-3}$	$5.0\ 10^{-2}$
Cow liver	$0.0\ 10^{0}$	$3.2\ 10^{-2}$	$2.9\ 10^{-7}$	$8.9\ 10^{-6}$	$1.1\ 10^{-5}$	$8.6\ 10^{-6}$	$4.5\ 10^{-4}$
Cow meat	$0.0\ 10^{0}$	$1.9\ 10^{-1}$	$1.7\ 10^{-8}$	$5.3\ 10^{-7}$	$6.6\ 10^{-5}$	$5.2\ 10^{-5}$	$2.7\ 10^{-3}$
Cow milk	$0.0\ 10^{0}$	$6.9\ 10^{0}$	$6.9\ 10^{-6}$	$6.9\ 10^{-5}$	$1.4\ 10^{-3}$	$1.1\ 10^{-3}$	$3.7\ 10^{-1}$
Cow milk products	$0.0\ 10^{0}$	$5.8\ 10^{0}$	$1.1\ 10^{-5}$	$1.1\ 10^{-4}$	$2.2\ 10^{-3}$	$1.7\ 10^{-3}$	$2.3\ 10^{-2}$
Fruit	$0.0\ 10^{0}$	$3.9\ 10^{-1}$	$1.1\ 10^{-6}$	$1.3\ 10^{-5}$	$8.7\ 10^{-5}$	$6.2\ 10^{-5}$	$9.3\ 10^{-3}$
Green vegetables	$0.0\ 10^{0}$	$2.1\ 10^{-1}$	$3.8\ 10^{-6}$	$3.5\ 10^{-5}$	$1.8\ 10^{-5}$	$1.4\ 10^{-5}$	$5.2\ 10^{-3}$
Root vegetables	$0.0\ 10^{0}$	$6.4\ 10^{-1}$	$3.2\ 10^{-8}$	$4.7\ 10^{-6}$	$5.0\ 10^{-5}$	$3.8\ 10^{-5}$	$1.6\ 10^{-2}$
Sheep liver	$0.0\ 10^{0}$	$3.2\ 10^{-2}$	$4.9\ 10^{-7}$	$1.3\ 10^{-5}$	$2.2\ 10^{-5}$	$1.8\ 10^{-5}$	$4.5\ 10^{-4}$
Sheep meat	$0.0\ 10^{0}$	$5.2\ 10^{-2}$	$7.3\ 10^{-9}$	$2.1\ 10^{-7}$	$3.4\ 10^{-5}$	$2.9\ 10^{-5}$	$7.3\ 10^{-4}$
Total	**$2.4\ 10^{-2}$**	**$1.5\ 10^{1}$**	**$1.6\ 10^{-4}$**	**$5.8\ 10^{-3}$**	**$5.3\ 10^{-3}$**	**$5.3\ 10^{-3}$**	**$4.8\ 10^{-1}$**

Table A5.9 continued

Radionuclide / Pathway	I-131	I-133	Kr-85	Xe-131m	Xe-133	Xe-135	Total
Plume at 250m	$4.0\ 10^{-3}$	$1.2\ 10^{-3}$	$1.8\ 10^{-3}$	$2.8\ 10^{-5}$	$1.8\ 10^{-2}$	$3.6\ 10^{-2}$	**$1.2\ 10^{0}$**
Cow liver	$3.4\ 10^{-4}$	$4.4\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$3.3\ 10^{-2}$**
Cow meat	$1.6\ 10^{-3}$	$2.4\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$2.0\ 10^{-1}$**
Cow milk	$5.1\ 10^{-1}$	$9.7\ 10^{-3}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$7.8\ 10^{0}$**
Cow milk products	$7.2\ 10^{-1}$	$6.7\ 10^{-3}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$6.6\ 10^{0}$**
Fruit	$7.2\ 10^{-3}$	$4.2\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$4.0\ 10^{-1}$**
Green vegetables	$5.6\ 10^{-3}$	$2.5\ 10^{-4}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$2.3\ 10^{-1}$**
Root vegetables	$3.5\ 10^{-3}$	$5.6\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$6.6\ 10^{-1}$**
Sheep liver	$4.3\ 10^{-4}$	$2.7\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$3.3\ 10^{-2}$**
Sheep meat	$3.8\ 10^{-4}$	1.6E-08	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$5.3\ 10^{-2}$**
Total	**$1.3\ 10^{0}$**	**$1.8\ 10^{-2}$**	**$1.8\ 10^{-3}$**	**$2.8\ 10^{-5}$**	**$1.8\ 10^{-2}$**	**$3.6\ 10^{-2}$**	**$1.7\ 10^{1}$**

* The generic infant is assumed to live 250m from release point and eat food produced 500m from release point

Table A5.10. Annual dose (μSv) to Adult with generic habits from liquid releases in 60th year of operation of SZC

Radionuclide / Pathway	Ag-110m	C-14	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H-3
Crustacea	$1.9\ 10^{-2}$	$2.9\ 10^{0}$	$2.4\ 10^{-3}$	$2.3\ 10^{-2}$	$4.0\ 10^{-7}$	$7.3\ 10^{-4}$	$9.3\ 10^{-4}$	$5.2\ 10^{-3}$
Fish - Sea	$1.0\ 10^{-3}$	$1.7\ 10^{0}$	$1.3\ 10^{-4}$	$1.3\ 10^{-3}$	$8.4\ 10^{-8}$	$1.4\ 10^{-3}$	$1.8\ 10^{-3}$	$2.9\ 10^{-3}$
Mollusca	$3.7\ 10^{-2}$	$2.9\ 10^{0}$	$1.2\ 10^{-3}$	$1.2\ 10^{-2}$	$6.5\ 10^{-7}$	$7.3\ 10^{-4}$	$9.3\ 10^{-4}$	$5.2\ 10^{-3}$
Seaweed	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
External beta from beaches	$3.0\ 10^{-5}$	$3.3\ 10^{-4}$	$1.1\ 10^{-5}$	$7.4\ 10^{-4}$	$1.5\ 10^{-10}$	$3.4\ 10^{-5}$	$4.6\ 10^{-4}$	$0.0\ 10^{0}$
External beta from fishing equipment	$2.9\ 10^{-6}$	$2.1\ 10^{-3}$	$3.2\ 10^{-6}$	$3.6\ 10^{-4}$	$0.0\ 10^{0}$	$8.5\ 10^{-6}$	$1.1\ 10^{-4}$	$0.0\ 10^{0}$

Radionuclide / Pathway	Ag-110m	C-14	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H-3
External gamma from beaches	$2.0\ 10^{-3}$	$0.0\ 10^{0}$	$9.4\ 10^{-3}$	$9.6\ 10^{-1}$	$2.1\ 10^{-6}$	$8.4\ 10^{-3}$	$2.7\ 10^{-2}$	$0.0\ 10^{0}$
External gamma from fishing equipment	$2.0\ 10^{-5}$	$0.0\ 10^{0}$	$9.4\ 10^{-5}$	$9.6\ 10^{-3}$	$2.1\ 10^{-8}$	$8.4\ 10^{-5}$	$2.7\ 10^{-4}$	$0.0\ 10^{0}$
Sea spray inhalation	$3.2\ 10^{-9}$	$1.6\ 10^{-7}$	$1.3\ 10^{-9}$	$1.7\ 10^{-8}$	$6.7\ 10^{-13}$	$2.8\ 10^{-9}$	$3.7\ 10^{-9}$	$2.4\ 10^{-6}$
Total	**$5.9\ 10^{-2}$**	**$7.6\ 10^{0}$**	**$1.3\ 10^{-2}$**	**$1.0\ 10^{0}$**	**$3.2\ 10^{-6}$**	**$1.1\ 10^{-2}$**	**$3.2\ 10^{-2}$**	**$1.3\ 10^{-2}$**

Table A5.10 continued

Radionuclide / Pathway	I-131	Mn-54	Ni-63	Sb-124	Sb-125	Te-123m	Total
Crustacea	$5.6\ 10^{-6}$	$1.8\ 10^{-5}$	$7.4\ 10^{-5}$	$5.1\ 10^{-5}$	$5.8\ 10^{-5}$	$7.5\ 10^{-4}$	**$3.0\ 10^{0}$**
Fish – Sea	$2.8\ 10^{-6}$	$8.0\ 10^{-6}$	$4.5\ 10^{-5}$	$4.3\ 10^{-4}$	$5.2\ 10^{-4}$	$4.0\ 10^{-4}$	**$1.7\ 10^{0}$**
Mollusca	$5.6\ 10^{-6}$	$1.8\ 10^{-3}$	$1.5\ 10^{-4}$	$4.1\ 10^{-5}$	$4.6\ 10^{-5}$	$7.5\ 10^{-4}$	**$3.0\ 10^{0}$**
Seaweed	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$0.0\ 10^{0}$**
External beta from beaches	$3.7\ 10^{-10}$	$6.2\ 10^{-8}$	$0.0\ 10^{0}$	$1.7\ 10^{-6}$	$9.1\ 10^{-6}$	$5.8\ 10^{-8}$	**$1.6\ 10^{-3}$**
External beta from fishing equipment	$9.5\ 10^{-11}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.4\ 10^{-7}$	$3.8\ 10^{-6}$	$1.4\ 10^{-7}$	**$2.6\ 10^{-3}$**
External gamma from beaches	$2.0\ 10^{-8}$	$5.5\ 10^{-3}$	$0.0\ 10^{0}$	$2.1\ 10^{-4}$	$1.7\ 10^{-3}$	$2.2\ 10^{-5}$	**$1.0\ 10^{0}$**
External gamma from fishing equipment	$2.0\ 10^{-10}$	$5.5\ 10^{-5}$	$0.0\ 10^{0}$	$2.1\ 10^{-6}$	$1.7\ 10^{-5}$	$2.2\ 10^{-7}$	**$1.0\ 10^{-2}$**
Sea spray inhalation	$5.7\ 10^{-11}$	$2.0\ 10^{-10}$	$3.3\ 10^{-10}$	$1.6\ 10^{-9}$	$3.2\ 10^{-9}$	$6.7\ 10^{-10}$	**$2.6\ 10^{-6}$**
Total	**$1.4\ 10^{-5}$**	**$7.4\ 10^{-3}$**	**$2.7\ 10^{-4}$**	**$7.3\ 10^{-4}$**	**$2.3\ 10^{-3}$**	**$1.9\ 10^{-3}$**	**$8.7\ 10^{0}$**

Table A5.11 Annual dose (µSv) to Child with generic habits from liquid releases in 60th year of operation of SZC

Radionuclide / Pathway	Ag-110m	C-14	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H-3
Crustacea	8.6 10^{-3}	1.0 10^{0}	1.4 10^{-3}	1.9 10^{-2}	2.1 10^{-7}	1.4 10^{-4}	1.8 10^{-4}	1.7 10^{-3}
Fish – Sea	3.8 10^{-4}	4.7 10^{-1}	5.9 10^{-5}	8.3 10^{-4}	3.5 10^{-8}	2.0 10^{-4}	2.7 10^{-4}	7.5 10^{-4}
Mollusca	1.7 10^{-2}	1.0 10^{0}	6.8 10^{-4}	9.4 10^{-3}	3.3 10^{-7}	1.4 10^{-4}	1.8 10^{-4}	1.7 10^{-3}
Seaweed	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}
External beta from beaches	3.0 10^{-5}	3.3 10^{-4}	1.1 10^{-5}	7.4 10^{-4}	1.5 10^{-10}	3.4 10^{-5}	4.6 10^{-4}	0.0 10^{0}
External beta from fishing equipment	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}
External gamma from beaches	2.0 10^{-3}	0.0 10^{0}	9.4 10^{-3}	9.6 10^{-1}	2.1 10^{-6}	8.4 10^{-3}	2.7 10^{-2}	0.0 10^{0}
External gamma from fishing equipment	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}
Sea spray inhalation	3.5 10^{-9}	1.6 10^{-7}	1.3 10^{-9}	1.8 10^{-8}	8.3 10^{-13}	1.6 10^{-9}	2.1 10^{-9}	2.1 10^{-6}
Total	**2.8 10^{-2}**	**2.5 10^{0}**	**1.2 10^{-2}**	**9.9 10^{-1}**	**2.6 10^{-6}**	**8.9 10^{-3}**	**2.8 10^{-2}**	**4.1 10^{-3}**

Table A5.11 continued

Radionuclide / Pathway	I-131	Mn-54	Ni-63	Sb-124	Sb-125	Te-123m	Total
Crustacea	3.3 10^{-6}	8.4 10^{-6}	3.5 10^{-5}	2.7 10^{-5}	2.8 10^{-5}	3.7 10^{-4}	**1.0 10^{0}**
Fish – Sea	1.3 10^{-6}	2.9 10^{-6}	1.7 10^{-5}	1.8 10^{-4}	2.0 10^{-4}	1.6 10^{-4}	**4.7 10^{-1}**
Mollusca	3.3 10^{-6}	8.4 10^{-4}	6.9 10^{-5}	2.1 10^{-5}	2.2 10^{-5}	3.7 10^{-4}	**1.0 10^{0}**
Seaweed	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	**0.0 10^{0}**
External beta from beaches	3.7 10^{-10}	6.2 10^{-8}	0.0 10^{0}	1.7 10^{-6}	9.1 10^{-6}	5.8 10^{-8}	**1.6 10^{-3}**
External beta from fishing equipment	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	**0.0 10^{0}**
External gamma from beaches	2.0 10^{-8}	5.5 10^{-3}	0.0 10^{0}	2.1 10^{-4}	1.7 10^{-3}	2.2 10^{-5}	**1.0 10^{0}**

Radionuclide / Pathway	I-131	Mn-54	Ni-63	Sb^{-12}4	Sb^{-12}5	Te-123m	Total
External gamma from fishing equipment	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$0.0\ 10^{0}$**
Sea spray inhalation	$1.0\ 10^{-10}$	$2.2\ 10^{-10}$	$3.4\ 10^{-10}$	$1.7\ 10^{-9}$	$3.1\ 10^{-9}$	$6.6\ 10^{-10}$	**$2.3\ 10^{-6}$**
Total	**$8.0\ 10^{-6}$**	**$6.3\ 10^{-3}$**	**$1.2\ 10^{-4}$**	**$4.3\ 10^{-4}$**	**$2.0\ 10^{-3}$**	**$9.2\ 10^{-4}$**	**$3.6\ 10^{0}$**

Table A5.12 Annual dose (μSv) to Infant with generic habits from liquid releases in 60th year of operation of SZC

Radionuclide / Pathway	Ag-110m	C^{-14}	Co-58	Co-60	Cr-51	Cs-134	Cs-137	H^{-3}
Crustacea	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Fish – Sea	$2.5\ 10^{-4}$	$2.3\ 10^{-1}$	$3.8\ 10^{-5}$	$5.1\ 10^{-4}$	$2.5\ 10^{-8}$	$5.7\ 10^{-5}$	$8.2\ 10^{-5}$	$3.9\ 10^{-4}$
Mollusca	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Seaweed	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
External beta from beaches	$3.0\ 10^{-5}$	$3.3\ 10^{-4}$	$1.1\ 10^{-5}$	$7.4\ 10^{-4}$	$1.5\ 10^{-10}$	$3.4\ 10^{-5}$	$4.6\ 10^{-4}$	$0.0\ 10^{0}$
External beta from fishing equipment	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
External gamma from beaches	$2.0\ 10^{-3}$	$0.0\ 10^{0}$	$9.4\ 10^{-3}$	$9.6\ 10^{-1}$	$2.1\ 10^{-6}$	$8.4\ 10^{-3}$	$2.7\ 10^{-2}$	$0.0\ 10^{0}$
External gamma from fishing equipment	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Sea spray inhalation	$2.7\ 10^{-9}$	$1.3\ 10^{-7}$	$1.2\ 10^{-9}$	$1.4\ 10^{-8}$	$9.0\ 10^{-13}$	$7.4\ 10^{-10}$	$1.0\ 10^{-9}$	$1.5\ 10^{-6}$
Total	**$2.3\ 10^{-3}$**	**$2.3\ 10^{-1}$**	**$9.5\ 10^{-3}$**	**$9.6\ 10^{-1}$**	**$2.1\ 10^{-6}$**	**$8.5\ 10^{-3}$**	**$2.8\ 10^{-2}$**	**$3.9\ 10^{-4}$**

Table A5.12 continued

Radionuclide / Pathway	I-131	Mn-54	Ni-63	Sb-124	Sb-125	Te-123m	Total
Crustacea	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$0.0\ 10^{0}$**
Fish – Sea	$1.2\ 10^{-6}$	$1.8\ 10^{-6}$	$1.2\ 10^{-5}$	$1.4\ 10^{-4}$	$1.4\ 10^{-4}$	$1.2\ 10^{-4}$	**$2.3\ 10^{-1}$**
Mollusca	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$0.0\ 10^{0}$**

Radionuclide / Pathway	I-131	Mn-54	Ni-63	Sb-124	Sb-125	Te-123m	Total
Seaweed	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$0.0\ 10^{0}$**
External beta from beaches	$3.7\ 10^{-10}$	$6.2\ 10^{-8}$	$0.0\ 10^{0}$	$1.7\ 10^{-6}$	$9.1\ 10^{-6}$	$5.8\ 10^{-8}$	**$1.6\ 10^{-3}$**
External beta from fishing equipment	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$0.0\ 10^{0}$**
External gamma from beaches	$2.0\ 10^{-8}$	$5.5\ 10^{-3}$	$0.0\ 10^{0}$	$2.1\ 10^{-4}$	$1.7\ 10^{-3}$	$2.2\ 10^{-5}$	**$1.0\ 10^{0}$**
External gamma from fishing equipment	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	**$0.0\ 10^{0}$**
Sea spray inhalation	$1.3\ 10^{-10}$	$1.9\ 10^{-10}$	$3.1\ 10^{-10}$	$1.4\ 10^{-9}$	$2.5\ 10^{-9}$	$5.1\ 10^{-10}$	**$1.6\ 10^{-6}$**
Total	**$1.2\ 10^{-6}$**	**$5.5\ 10^{-3}$**	**$1.2\ 10^{-5}$**	**$3.4\ 10^{-4}$**	**$1.8\ 10^{-3}$**	**$1.5\ 10^{-4}$**	**$1.2\ 10^{0}$**

References

1. Garrod, C.J., Clyne, F.J. and Rumney, P., 2016. Radiological habits survey: Sizewell, 2015. Cefas, Lowestoft, RL 01/16.

Appendix 6 Additional data for assessment of direct shine

The approach used to model direct shine is based on that used in (NNB GenCo (SZC), 2020). It assumes that the outside of any building is an undesignated area and is therefore subject to the annual dose limit of 1 mSv y^{-1} for non-radiation workers under IRR17 (UK Parliament, 2017). This is equivalent to an exposure rate of 0.5 μSv h^{-1} for 2000 hours y^{-1}. The dose rate of 0.5 μSv h^{-1} is assumed to be the value outside the building, situated 1 m from the source, and can be extrapolated to a dose at the locations occupied by the public. The method of extrapolation depends on the distance of the exposed individual from the source. For distances of less than about three building lengths it is assumed that exposure is to an extended source and it is recommended that the dose decreases by a factor of 1/r where r is the distance between the building and the exposed individual. At greater distances, exposure to a point source can be assumed and a factor of $1/r^2$ is recommended.

To model skyshine (the exposure pathway that occurs when direct radiation from the source is scattered from the atmosphere back to the ground) it would be preferable to use an MCNP approach such as that described in (Bryant et al, 2016). However, given the uncertainty in the source term and the fact that this is not part of the remit of EA such an approach is not justified for this assessment. Instead a simple qualitative discussion based on the direct shine assessment is provided. The dose at ground level from skyshine is mainly due to photons that have undergone Compton scattering. This has the effect of reducing the photon energy especially where the angle of scatter is large i.e. close to the building. Further from the building the photon energies will decrease less due to scattering but the influence of distance from the source will be more significant. In summary, it is likely that the skyshine dose will be less than the direct shine dose. If the conservative assumption is made that both are equal then even for the Sizewell B worker (Table 8) the annual dose is expected to be less than 8 μSv. This is a small contribution to the overall dose and a more detailed assessment is not necessary at this time. However, it is expected that direct exposure will be considered in more detail by the operator and ONR once the designs of the ISFS and ILWS have been finalised.

NNB GenCo (SZC) calculated direct shine doses to a dog walker, Sizewell B worker and local resident (NNB GenCo (SZC), 2020). These doses are consistent with those calculated in this report (Table 8). However, this report also calculated the direct shine dose to important CRPs as defined in the CEFAS report (Garrod et al, 2016). These CRPs are presented in Table 4.1 and include the RP, 'Adult sea fish consumers'. The dose to the 'Adult sea fish consumers' can be added to the total dose to the RP as detailed in Section 6.

Table A6.1 Input data for direct shine dose calculation

A dose rate of 5 μSv h^{-1} at 1 m from the outside wall of spent fuel and radioactive waste stores was used in the calculations. The building width and locations used were as follows:

- Spent fuel store = 202 m (TM47106394)
- ILW store = 137 m (TM47106417)

This data was taken from the NNB GenCo (SZC) dose assessment (NNB GenCo (SZC), 2019).

Parameter	Distance from spent fuel store	Distance from ILW store	Occupancy at location	Fraction of time spent indoors	Indoor shielding factor	Comments
Dog walker	N/A	190 m	182.5 h y^{-1}	0%	N/A	Assume daily walk, spending half an hour at this location.
Resident	1000 m	1000 m	8760 h y^{-1}	90%	90% reduction	-
Sizewell B worker	150 m	477 m	2000 h y^{-1}	50%	90% reduction	-
Adult Plume IN (0 to 0.25 km) (CRP)	580 m	530 m	6870 h y^{-1}	90%	90% reduction	No occupancy data provided for Plume (MID: >0.25 to 0.5 km) or Plume (OUT: >0.5 to 1 km)
Adult Plume MID (>0.25 to 0.5 km) (CRP)	1190 m	1410 m	8020 h y^{-1}	90%	90% reduction	No occupancy data provided for Plume (IN: 0 to 0.25 km) or Plume (OUT: >0.5 to 1 km)
Adult Plume OUT (>0.5 to 1 km) (CRP)	1770 m	1990 m	7460 h y^{-1}	90%	90% reduction	No occupancy data provided for Plume IN (0 to 0.25 km) or Plume MID (>0.25 to 0.5 km)

Parameter	Distance from spent fuel store	Distance from ILW store	Occupancy at location	Fraction of time spent indoors	Indoor shielding factor	Comments
Adult sea fish consumers (RP)	580 m	530 m	190 h y^{-1}	0%	N/A	No occupancy data provided for Plume OUT (>0.5 to 1 km)
Includes Plume IN and Plume MID.	1190 m	1410 m	220 h y^{-1}	0%	N/A	-

References

1. Bryant, P.A., Haemmerli, V., Jones, T., Trerise, S., O'brien, F. and Meadows, R., 2016. A comparison of a hand calculation tool and a Monte Carlo method for determining skyshine doses from the on-site storage of radioactive waste. Radiation Regulator **2**.

2. Garrod, C.J., Clyne, F.J. and Rumney, P., 2016. Radiological habits survey: Sizewell, 2015. Cefas, Lowestoft, RL 01/16.

3. Nuclear New Build Generation Company (SZC) Limited, 2019. SZC Human Radiological Impact Assessment. NNB GenCo (SZC) Ltd, London, Document 100197432 Version 0.5.

4. Nuclear New Build Generation Company (SZC) Limited, 2020. Sizewell C project RSR Permit application: Support Document D1 - Human Radiological Impact Assessment. NNB GenCo (SZC) Ltd, London, Document 100197432 Version 1.0.

5. UK Parliament, 2017. The Ionising Radiations Regulations 2017. (SI 2017/1075)

Appendix 7 Additional data for short-term discharges

This appendix presents data related to the assessment of doses from short-term discharges to atmosphere. Assessment data include input parameter values to ADMS 4.2 (Table A7.1), dose coefficients for radionuclides in the SZC source term but which are not considered in the NDAWG/NRPB-W54 guidance (Table A7.2) and habit data (Table A7.3). The habit data are for two sets of individuals. The first set pertains to four habits profiles from the CEFAS study (Garrod et al, 2016): 'Adult sea fish consumers' (the RP), 'Child mollusc consumers', 'Infant sea fish consumers' and the 'Adult Plume 0 to 0.25 km' group. The second set uses generalised UK habits data which can be used where sit 10-specific information is unavailable and provides a useful comparison. Outputs presented here include ADMS 4.2 results (Table A7.4), activity concentrations in foods (Table A7.5) and a breakdown of dose by radionuclide and pathway (Tables A7.6 to A7.12).

The exposure pathways considered are listed in Table A7.6. Some exposure pathways are only relevant during the passage of the radioactive plume, these are inhalation and external exposure to beta and gamma radiation in the plume. Other exposure pathways are relevant during and after the initial passing of the plume, these include ingestion, gamma irradiation from deposited radionuclides and inhalation of resuspended material. Doses from all these pathways are calculated for a single location as discussed in Section 5. The dose from a short-term release can be added to the dose from routine releases provided the latter are corrected to account for the fraction of the annual release that occurred during the short-term release (Environment Agency et al, 2012). The following is a summary of the equations used to calculate doses from a short-term release.

Inhalation of radionuclides in the plume

Dose = AirConc x InhRate x PlumeTime x InhDC

External exposure to gamma radiation from the plume (Cloud gamma)

Dose = GammaDR x PlumeTime

External exposure to beta radiation from the plume (Cloud beta)

Dose = AirConc x BetaDC x PlumeTime x (years/hour)

Ingestion of radionuclides in food

Dose = DepRate x (seconds/hour) x PlumeTime x FoodConc x IngRate x IngDC

External exposure to gamma radiation from the ground (Ground gamma)

Dose = DepRate x (seconds/hour) x PlumeTime x GammaDose

Inhalation of resuspended radionuclides

Dose = DepRate x PlumeTime x ResusAirConc x InhRate x InhDC

Where:

Dose = Dose received during release and over subsequent 12 months (Sv)

AirConc = Activity concentration in the plume (Bq m^{-3}) from ADMS

InhRate = Inhalation rate (m^3 h^{-1})

PlumeTime = time for plume to pass, also equals release duration (h).

InhDC = Inhalation dose coefficient (Sv Bq^{-1})

GammaDR = Gamma dose rate (Sv h^{-1}) from ADMS

BetaDC = Beta dose rate coefficient (Sv y^{-1} per Bq m^{-3})

DepRate = Deposition rate (Bq m^{-2} s^{-1}) from ADMS

FoodConc = Activity concentrations in food integrated over one year per unit deposition (Bq y kg^{-1} per Bq m^{-2})

IngRate = Ingestion rate (kg y^{-1})

InhDC = Ingestion dose coefficient (Sv Bq^{-1})

GammaDose = Gamma dose received in one year per unit deposition (Sv per Bq m^{-3})

ResusAirConc = Resuspended activity concentration in air integrated over one year (Bq s m^{-3} per Bq m^{-2})

Table A7.1 Input parameter values for ADMS 4.2

Parameter	Value
Effective stack height (m)	20
Stack diameter (m)	3
Stack exit velocity (m s^{-1})	0 (set to zero to turn off plume rise)
Discharge gas	Air
Ambient temp. of discharge gases (°C)	15
Averaging period (h)	12
Surface roughness length (m)	0.3
Deposition velocity (m/s)	5.00 10^{-3} (tritium) 0 (noble gases and C-14) 1.00 10^{-2} (iodine) 1.00 10^{-3} (aerosols as Cs-137)
Washout*	A = 1 10^{-4} B = 0.64 (tritium) 0 (noble gases and C-14) A = 1 10^{-4} B = 0.64 (iodine) A = 1 10^{-4} B = 0.64 (aerosol as Cs-137)
Meteorological Data	NWP hourly sequential sit 10-specific data for Sizewell C for 2015-2019
Receptor point locations **Distance from source (m)** **Angle (clockwise from north) (°) #**	 500 30
.aai file	NOSTACKDOWNWASH

*Wet deposition was modelled using a washout coefficient Δ, calculated using the ADMS default parameters A and B, and rainfall rate P (mm/h). No wet deposition was assumed for noble gases. $\Delta = AP^{B}$ (1/s)

ADMS requires the angle to be anti-clockwise from east.

Table A7.2 Additional data for radionuclides in the SZC source term but not included in NDAWG guidance and NRPB-W54

Radionuclide	Ingestion DPUI ~ (Sv Bq-1) Adult	Ingestion DPUI ~ (Sv Bq-1) Child	Ingestion DPUI ~ (Sv Bq-1) Infant	Inhalation DPUI ~ (Sv Bq-1) Adult	Inhalation DPUI ~ (Sv Bq-1) Child	Inhalation DPUI ~ (Sv Bq-1) Infant	Cloud beta dose rates (Sv y^{-1} per Bq m^{-3}) *	Ground gamma dose (Sv per Bq m^{-2}) #	Resuspension (Bq s m^{-3} per Bq m^{-2}) @
Co-58	7.4 10^{-10}	1.7 10^{-9}	4.4 10^{-9}	1.6 10^{-9}	2.4 10^{-9}	6.5 10^{-9}	4.4 10-10	5.2 10^{-9}	5.3 10^{-1}
I-133	4.3 10^{-9}	1.0 10^{-8}	4.4 10^{-8}	1.5 10^{-9}	3.8 10^{-9}	1.8 10^{-8}	7.7 10^{-9}	4.7 10^{-11}	1.4 10^{-1}
Cs-134	1.9 10^{-8}	1.4 10^{-8}	1.6 10^{-8}	6.6 10^{-9}	5.3 10^{-9}	7.3 10^{-9}	2.4 10^{-9}	2.7 10^{-8}	7.1 10^{-1}
Xe-131m	-	-	-	-	-	-	1.3 10^{-9}	-	-
Xe-135	-	-	-	-	-	-	5.5 10^{-9}	-	-
Ar-41	-	-	-	-	-	-	8.9 10^{-9}	-	-
C-14	-	-	-	-	-	-	7.9 10^{-11}	-	-
Co-60	-	-	-	-	-	-	7.9 10^{-10}	-	7.3 10^{-1}
Cs-137	-	-	-	-	-	-	2.4 10^{-9}	-	7.4 10^{-1}
H-3	-	-	-	-	-	-	0.0 10^{0}	-	-
I-131	-	-	-	-	-	-	2.7 10^{-9}	-	3.1 10^{-1}
Kr-85	-	-	-	-	-	-	4.2 10^{-9}	-	-
Xe-133	-	-	-	-	-	-	9.0 10^{-10}	-	-

*Based on beta skin dose rate and tissue weighting factor of 0.01 (Smith and Simmonds, 2009)

Gamma dose rate received over period of a year following deposition (Charnock et al, 2014)

@ Resuspended activity concentration in air (Wellings et al, 2019)

~ ICRP dose coefficients as presented in (Smith and Simmonds, 2009)

Table A7.3a Habit data used for short-term atmospheric release assessment of selected CRP groups

Parameter	Adult sea fish consumers	Child sea fish consumers	Infant sea fish consumers	Adult Plume IN 0 to 0.25 km
Fraction of time outdoors during passage of plume	100%	100%	100%	100%
Fraction of time outdoors in subsequent 12 months	100%	100%	100%	100%
Inhalation rate ($m^3 h^{-1}$)	0.92	0.64	0.22	0.92
Ingestion rates ($kg y^{-1}$)Green vegetables	6.6	0	0	2.1
Ingestion rates ($kg y^{-1}$) Soft fruit	2.0	0	0	4.2
Ingestion rates ($kg y^{-1}$) Potatoes	7.2	0	0	4.8
Ingestion rates ($kg y^{-1}$) Carrots	3.8	0	0	4.0
Ingestion rates ($kg y^{-1}$) Milk	0	0	0	0
Ingestion rates ($kg y^{-1}$) Milk products	0	0	0	0
Ingestion rates ($kg y^{-1}$) Cow meat	0	0	0	0
Ingestion rates ($kg y^{-1}$) Cow liver	0	0	0	0
Ingestion rates ($kg y^{-1}$) Sheep meat	0	0	0	0
Ingestion rates ($kg y^{-1}$) Sheep liver	0	0	0	0

Ingestion rates from (Garrod et al, 2016)

Table A7.3b Habit data used for short-term atmospheric release assessment of generic groups

Parameter	Adult	Child	Infant
Fraction of time outdoors during passage of plume	100%	100%	100%
Fraction of time outdoors in subsequent 12 months	100%	100%	100%
Inhalation rate (m^3 h^{-1})	0.92	0.64	0.22
Ingestion rates (kg y^{-1}) Green vegetables	35	15	5.0
Ingestion rates (kg y^{-1}) Soft fruit	20	15	9.0
Ingestion rates (kg y^{-1}) Potatoes	50	45	10
Ingestion rates (kg y^{-1}) Carrots	10	5.0	5.0
Ingestion rates (kg y^{-1}) Milk	240	240	320
Ingestion rates (kg y^{-1}) Milk products	60	45	45
Ingestion rates (kg y^{-1}) Cow meat	15	15	3.0
Ingestion rates (kg y^{-1}) Cow liver	2.8	1.5	0.5
Ingestion rates (kg y^{-1}) Sheep meat	8.0	4.0	0.8
Ingestion rates (kg y^{-1}) Sheep liver	2.8	1.5	0.5

Ingestion rates from PC-CREAM 08 for average consumers except those in bold which use critical rates.

Table A7.4 ADMS results for expected short-term discharges from SZC, 500 m from discharge stack, 30° clockwise from north.

Radionuclide	Average activity concentration in air during passage of the plume (Bq m^{-3})	Deposition rate (Bq m^{-2} s^{-1})	Cloud gamma dose rate (Sv s^{-1})
H-3	9.3 10^{1}	4.7 10^{-1}	0.0 10^{0}
C-14	2.5 10^{1}	0.0 10^{0}	0.0 10^{0}
Ar-41	2.3 10^{1}	0.0 10^{0}	5.6 10^{-13}
Co-60	2.2 10^{-4}	2.2 10^{-7}	1.1 10^{-17}
Co-58	1.9 10^{-4}	1.9 10^{-7}	3.8 10-18
Kr-85	1.1 10^{2}	0.0 10^{0}	5.3 10^{-15}
I-133	1.0 10^{-3}	1.0 10^{-5}	1.6 10^{-17}
I-131	5.4 10^{-3}	5.4 10^{-5}	5.5 10^{-17}
Xe-133	5.1 10^{2}	0.0 10^{0}	5.2 10^{-13}
Cs-137	1.6 10^{-4}	1.6 10^{-7}	1.3 10^{-18}
Cs-134	1.7 10^{-4}	1.7 10^{-7}	5.7 10^{-18}
Xe-131m	2.4 10^{0}	0.0 10^{0}	6.2 10^{-16}
Xe-135	1.6 10^{2}	0.0 10^{0}	9.0 10^{-13}

Table A7.5 Activity concentrations in foods integrated over one year (Bq y kg^{-1} per Bq m^{-2}) for proposed discharges from SZC in summer. Location is 500 m from discharge stack and 30° clockwise from north.

Radionuclide	Green vegetables	Soft fruit	Potatoes	Carrots	Milk	Cow meat	Cow liver	Sheep meat	Sheep liver
H-3	$2.0\ 10^{-3}$	$2.0\ 10^{-3}$	$2.0\ 10^{-3}$	$2.0\ 10^{-3}$	$9.1\ 10^{-4}$	$7.8\ 10^{-4}$	$7.8\ 10^{-4}$	$1.2\ 10^{-3}$	$1.2\ 10^{-3}$
C-14 #	$3.7\ 10^{-1}$	$3.7\ 10^{-1}$	$3.6\ 10^{-1}$	$3.6\ 10^{-1}$	$4.9\ 10^{-1}$	$1.9\ 10^{0}$	$1.9\ 10^{0}$	$3.8\ 10^{0}$	$3.8\ 10^{0}$
Co-60	$3.2\ 10^{-3}$	$1.9\ 10^{-3}$	$4.1\ 10^{-5}$	$4.6\ 10^{-5}$	$4.2\ 10^{-3}$	$1.1\ 10^{-3}$	$1.1\ 10^{-1}$	$9.7\ 10^{-4}$	$9.7\ 10^{-2}$
Co-58 *	$3.2\ 10^{-3}$	$1.9\ 10^{-3}$	$4.1\ 10^{-5}$	$4.6\ 10^{-5}$	$4.2\ 10^{-3}$	$1.1\ 10^{-3}$	$1.1\ 10^{-1}$	$9.7\ 10^{-4}$	$9.7\ 10^{-2}$
I-133 *	$1.3\ 10^{-3}$	$3.0\ 10^{-3}$	$2.7\ 10^{-4}$	$2.6\ 10^{-4}$	$1.8\ 10^{-3}$	$7.8\ 10^{-4}$	$7.8\ 10^{-4}$	$1.0\ 10^{-3}$	$1.0\ 10^{-3}$
I-131	$1.3\ 10^{-3}$	$3.0\ 10^{-3}$	$2.7\ 10^{-4}$	$2.6\ 10^{-4}$	$1.8\ 10^{-3}$	$7.8\ 10^{-4}$	$7.8\ 10^{-4}$	$1.0\ 10^{-3}$	$1.0\ 10^{-3}$
Cs-137	$3.7\ 10^{-3}$	$3.7\ 10^{-2}$	$9.5\ 10^{-3}$	$3.6\ 10^{-3}$	$1.1\ 10^{-2}$	$5.5\ 10^{-2}$	$5.5\ 10^{-2}$	$4.6\ 10^{-2}$	$4.6\ 10^{-2}$
Cs-134 *	$3.7\ 10^{-3}$	$3.7\ 10^{-2}$	$9.5\ 10^{-3}$	$3.6\ 10^{-3}$	$1.1\ 10^{-2}$	$5.5\ 10^{-2}$	$5.5\ 10^{-2}$	$4.6\ 10^{-2}$	$4.6\ 10^{-2}$

* Values for Co-58, I-133 and Cs-134 assumed to be the same as Co-60, I-131 and Cs-137.

Units are Bq y kg^{-1} per Bq m^{-3}.

Table A7.6 Annual effective dose (µSv) to adult sea fish consumers from short-term atmospheric release from SZC

Radionuclide	Green vegetables	Soft fruit	Potatoes	Carrots	Cow meat	Cow liver	Sheep meat	Sheep liver
Ar-41	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
C-14	$3.6\ 10^{-2}$	$1.1\ 10^{-2}$	$3.8\ 10^{-2}$	$2.0\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Co-58	$1.3\ 10^{-7}$	$2.3\ 10^{-8}$	$1.8\ 10^{-9}$	$1.1\ 10^{-9}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Co-60	$6.9\ 10^{-7}$	$1.2\ 10^{-7}$	$9.6\ 10^{-9}$	$5.7\ 10^{-9}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Cs-134	$3.5\ 10^{-6}$	$1.1\ 10^{-5}$	$9.8\ 10^{-6}$	$2.0\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Cs-137	$2.2\ 10^{-6}$	$6.5\ 10^{-6}$	$6.0\ 10^{-6}$	$1.2\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
H-3	$5.9\ 10^{-3}$	$1.8\ 10^{-3}$	$6.4\ 10^{-3}$	$3.4\ 10^{-3}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
I-131	$4.3\ 10^{-4}$	$3.1\ 10^{-4}$	$1.0\ 10^{-4}$	$5.1\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
I-133	$1.6\ 10^{-5}$	$1.2\ 10^{-5}$	$3.8\ 10^{-6}$	$1.9\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Kr-85	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Xe-131m	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Xe-133	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Xe-135	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Total	$4.2\ 10^{-2}$	$1.3\ 10^{-2}$	$4.5\ 10^{-2}$	$2.4\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$

Table A7.6 continued

Radionuclide	Cloud Beta	Cloud Gamma	Dep Gamma	Inhalation	R 10-suspension	Total
Ar-41	$2.8\ 10^{-4}$	$2.4\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.4\ 10^{-2}$
C-14	$2.7\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.6\ 10^{-1}$	$0.0\ 10^{0}$	$4.7\ 10^{-1}$
Co-58	$1.1\ 10^{-10}$	$1.7\ 10^{-7}$	$4.3\ 10^{-5}$	$3.4\ 10^{-6}$	$1.8\ 10^{-9}$	$4.6\ 10^{-5}$
Co-60	$2.4\ 10^{-10}$	$4.7\ 10^{-7}$	$4.2\ 10^{-4}$	$2.5\ 10^{-5}$	$1.8\ 10^{-8}$	$4.5\ 10^{-4}$
Cs-134	$5.7\ 10^{-10}$	$2.4\ 10^{-7}$	$2.0\ 10^{-4}$	$1.3\ 10^{-5}$	$9.0\ 10^{-9}$	$2.4\ 10^{-4}$
Cs-137	$5.1\ 10^{-10}$	$5.6\ 10^{-8}$	$7.3\ 10^{-5}$	$7.9\ 10^{-6}$	$5.9\ 10^{-9}$	$9.7\ 10^{-5}$
H-3	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.8\ 10^{-2}$	$0.0\ 10^{0}$	$3.6\ 10^{-2}$
I-131	$2.0\ 10^{-8}$	$2.4\ 10^{-6}$	$5.8\ 10^{-4}$	$4.4\ 10^{-4}$	$1.4\ 10^{-6}$	$1.9\ 10^{-3}$
I-133	$1.1\ 10^{-8}$	$7.0\ 10^{-7}$	$2.1\ 10^{-5}$	$1.7\ 10^{-5}$	$2.4\ 10^{-8}$	$7.3\ 10^{-5}$
Kr-85	$6.6\ 10^{-4}$	$2.3\ 10^{-4}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$8.9\ 10^{-4}$
Xe-131m	$4.3\ 10^{-6}$	$2.7\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.1\ 10^{-5}$
Xe-133	$6.3\ 10^{-4}$	$2.2\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.3\ 10^{-2}$
Xe-135	$1.2\ 10^{-3}$	$3.9\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$4.0\ 10^{-2}$
Total	$2.8\ 10^{-3}$	$8.6\ 10^{-2}$	$1.3\ 10^{-3}$	$3.8\ 10^{-1}$	$1.4\ 10^{-6}$	$5.9\ 10^{-1}$

Table A7.7 Annual effective dose (µSv) to child mollusc consumers from short-term atmospheric release from SZC

Radionuclide	Ingestion	Cloud Beta	Cloud Gamma	Dep Gamma	Inhalation	R 10-suspension	Total
Ar-41	$0.0\ 10^{0}$	$2.8\ 10^{-4}$	$2.4\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.4\ 10^{-2}$
C-14	$0.0\ 10^{0}$	$2.7\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.5\ 10^{-1}$	$0.0\ 10^{0}$	$3.5\ 10^{-1}$
Co-58	$0.0\ 10^{0}$	$1.1\ 10^{-10}$	$1.7\ 10^{-7}$	$4.3\ 10^{-5}$	$3.5\ 10^{-6}$	$1.9\ 10^{-9}$	$4.6\ 10^{-5}$
Co-60	$0.0\ 10^{0}$	$2.4\ 10^{-10}$	$4.7\ 10^{-7}$	$4.2\ 10^{-4}$	$2.6\ 10^{-5}$	$1.9\ 10^{-8}$	$4.5\ 10^{-4}$
Cs-134	$0.0\ 10^{0}$	$5.7\ 10^{-10}$	$2.4\ 10^{-7}$	$2.0\ 10^{-4}$	$7.1\ 10^{-6}$	$5.0\ 10^{-9}$	$2.1\ 10^{-4}$
Cs-137	$0.0\ 10^{0}$	$5.1\ 10^{-10}$	$5.6\ 10^{-8}$	$7.3\ 10^{-5}$	$4.4\ 10^{-6}$	$3.3\ 10^{-9}$	$7.7\ 10^{-5}$
H-3	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.6\ 10^{-2}$	$0.0\ 10^{0}$	$1.6\ 10^{-2}$
I-131	$0.0\ 10^{0}$	$2.0\ 10^{-8}$	$2.4\ 10^{-6}$	$5.8\ 10^{-4}$	$7.9\ 10^{-4}$	$2.4\ 10^{-6}$	$1.4\ 10^{-3}$
I-133	$0.0\ 10^{0}$	$1.1\ 10^{-8}$	$7.0\ 10^{-7}$	$2.1\ 10^{-5}$	$3.1\ 10^{-5}$	$4.2\ 10^{-8}$	$5.2\ 10^{-5}$
Kr-85	$0.0\ 10^{0}$	$6.6\ 10^{-4}$	$2.3\ 10^{-4}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$8.9\ 10^{-4}$
Xe-131m	$0.0\ 10^{0}$	$4.3\ 10^{-6}$	$2.7\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.1\ 10^{-5}$
Xe-133	$0.0\ 10^{0}$	$6.3\ 10^{-4}$	$2.2\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.3\ 10^{-2}$
Xe-135	$0.0\ 10^{0}$	$1.2\ 10^{-3}$	$3.9\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$4.0\ 10^{-2}$
Total	$0.0\ 10^{0}$	$2.8\ 10^{-3}$	$8.6\ 10^{-2}$	$1.3\ 10^{-3}$	$3.7\ 10^{-1}$	$2.5\ 10^{-6}$	$4.6\ 10^{-1}$

Table A7.8 Annual effective dose (μSv) to infant sea fish consumers from short-term atmospheric release from SZC

Radionuclide	Ingestion	Cloud Beta	Cloud Gamma	Dep Gamma	Inhalation	R 10-suspension	Total
Ar-41	$0.0\ 10^{0}$	$2.8\ 10^{-4}$	$2.4\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.4\ 10^{-2}$
C-14	$0.0\ 10^{0}$	$2.7\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.7\ 10^{-1}$	$0.0\ 10^{0}$	$2.7\ 10^{-1}$
Co-58	$0.0\ 10^{0}$	$1.1\ 10^{-10}$	$1.7\ 10^{-7}$	$4.3\ 10^{-5}$	$3.3\ 10^{-6}$	$1.7\ 10^{-9}$	$4.6\ 10^{-5}$
Co-60	$0.0\ 10^{0}$	$2.4\ 10^{-10}$	$4.7\ 10^{-7}$	$4.2\ 10^{-4}$	$2.0\ 10^{-5}$	$1.5\ 10^{-8}$	$4.4\ 10^{-4}$
Cs-134	$0.0\ 10^{0}$	$5.7\ 10^{-10}$	$2.4\ 10^{-7}$	$2.0\ 10^{-4}$	$3.4\ 10^{-6}$	$2.4\ 10^{-9}$	$2.1\ 10^{-4}$
Cs-137	$0.0\ 10^{0}$	$5.1\ 10^{-10}$	$5.6\ 10^{-8}$	$7.3\ 10^{-5}$	$2.2\ 10^{-6}$	$1.7\ 10^{-9}$	$7.5\ 10^{-5}$
H-3	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.2\ 10^{-2}$	$0.0\ 10^{0}$	$1.2\ 10^{-2}$
I-131	$0.0\ 10^{0}$	$2.0\ 10^{-8}$	$2.4\ 10^{-6}$	$5.8\ 10^{-4}$	$1.0\ 10^{-3}$	$3.2\ 10^{-6}$	$1.6\ 10^{-3}$
I-133	$0.0\ 10^{0}$	$1.1\ 10^{-8}$	$7.0\ 10^{-7}$	$2.1\ 10^{-5}$	$5.0\ 10^{-5}$	$6.8\ 10^{-8}$	$7.2\ 10^{-5}$
Kr-85	$0.0\ 10^{0}$	$6.6\ 10^{-4}$	$2.3\ 10^{-4}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$8.9\ 10^{-4}$
Xe-131m	$0.0\ 10^{0}$	$4.3\ 10^{-6}$	$2.7\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.1\ 10^{-5}$
Xe-133	$0.0\ 10^{0}$	$6.3\ 10^{-4}$	$2.2\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.3\ 10^{-2}$
Xe-135	$0.0\ 10^{0}$	$1.2\ 10^{-3}$	$3.9\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$4.0\ 10^{-2}$
Total	$0.0\ 10^{0}$	$2.8\ 10^{-3}$	$8.6\ 10^{-2}$	$1.3\ 10^{-3}$	$2.9\ 10^{-1}$	$3.3\ 10^{-6}$	$3.8\ 10^{-1}$

Table A7.9 Annual effective dose (µSv) to adult plume IN (0 to 0.25 km) group from short-term atmospheric release from SZC

Radionuclide	Green vegetables	Soft fruit	Potatoes	Carrots	Cow meat	Cow liver	Sheep meat	Sheep liver
Ar-41	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
C-14	$1.1\ 10^{-2}$	$2.3\ 10^{-2}$	$2.5\ 10^{-2}$	$2.1\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Co-58	$4.0\ 10^{-8}$	$4.8\ 10^{-8}$	$1.2\ 10^{-9}$	$1.1\ 10^{-9}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Co-60	$2.2\ 10^{-7}$	$2.6\ 10^{-7}$	$6.4\ 10^{-9}$	$6.0\ 10^{-9}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Cs-134	$1.1\ 10^{-6}$	$2.2\ 10^{-5}$	$6.5\ 10^{-6}$	$2.1\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Cs-137	$6.9\ 10^{-7}$	$1.4\ 10^{-5}$	$4.0\ 10^{-6}$	$1.3\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
H-3	$1.9\ 10^{-3}$	$3.8\ 10^{-3}$	$4.3\ 10^{-3}$	$3.6\ 10^{-3}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
I-131	$1.4\ 10^{-4}$	$6.5\ 10^{-4}$	$6.7\ 10^{-5}$	$5.4\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
I-133	$5.1\ 10^{-6}$	$2.4\ 10^{-5}$	$2.5\ 10^{-6}$	$2.0\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Kr-85	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Xe-131m	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Xe-133	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Xe-135	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Total	$1.3\ 10^{-2}$	$2.7\ 10^{-2}$	$3.0\ 10^{-2}$	$2.5\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$

Table A7.9 continued

Radionuclide	Cloud Beta	Cloud Gamma	Dep Gamma	Inhalation	R 10-suspension	Total
Ar-41	$2.8\ 10^{-4}$	$2.4\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.4\ 10^{-2}$
C-14	$2.7\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.6\ 10^{-1}$	$0.0\ 10^{0}$	$4.4\ 10^{-1}$
Co-58	$1.1\ 10^{-10}$	$1.7\ 10^{-7}$	$4.3\ 10^{-5}$	$3.4\ 10^{-6}$	$1.8\ 10^{-9}$	$4.6\ 10^{-5}$
Co-60	$2.4\ 10^{-10}$	$4.7\ 10^{-7}$	$4.2\ 10^{-4}$	$2.5\ 10^{-5}$	$1.8\ 10^{-8}$	$4.5\ 10^{-4}$
Cs-134	$5.7\ 10^{-10}$	$2.4\ 10^{-7}$	$2.0\ 10^{-4}$	$1.3\ 10^{-5}$	$9.0\ 10^{-9}$	$2.5\ 10^{-4}$
Cs-137	$5.1\ 10^{-10}$	$5.6\ 10^{-8}$	$7.3\ 10^{-5}$	$7.9\ 10^{-6}$	$5.9\ 10^{-9}$	$1.0\ 10^{-4}$
H-3	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.8\ 10^{-2}$	$0.0\ 10^{0}$	$3.2\ 10^{-2}$
I-131	$2.0\ 10^{-8}$	$2.4\ 10^{-6}$	$5.8\ 10^{-4}$	$4.4\ 10^{-4}$	$1.4\ 10^{-6}$	$1.9\ 10^{-3}$
I-133	$1.1\ 10^{-8}$	$7.0\ 10^{-7}$	$2.1\ 10^{-5}$	$1.7\ 10^{-5}$	$2.4\ 10^{-8}$	$7.3\ 10^{-5}$
Kr-85	$6.6\ 10^{-4}$	$2.3\ 10^{-4}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$8.9\ 10^{-4}$
Xe-131m	$4.3\ 10^{-6}$	$2.7\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.1\ 10^{-5}$
Xe-133	$6.3\ 10^{-4}$	$2.2\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.3\ 10^{-2}$
Xe-135	$1.2\ 10^{-3}$	$3.9\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$4.0\ 10^{-2}$
Total	$2.8\ 10^{-3}$	$8.6\ 10^{-2}$	$1.3\ 10^{-3}$	$3.8\ 10^{-1}$	$1.4\ 10^{-6}$	$5.7\ 10^{-1}$

Table A7.10 Annual effective dose (μSv) to adult with generic ingestion rates from short-term atmospheric release from SZC

Radionuclide	Green vegetables	Soft fruit	Potatoes	Carrots	Milk	Milk products	Cow meat	Cow liver	Sheep meat	Sheep liver
Ar-41	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
C-14	$1.9\ 10^{-1}$	$1.1\ 10^{-1}$	$2.6\ 10^{-1}$	$5.3\ 10^{-2}$	$1.7\ 10^{0}$	$2.6\ 10^{0}$	$4.2\ 10^{-1}$	$7.7\ 10^{-2}$	$4.4\ 10^{-1}$	$1.5\ 10^{-1}$
Co-58	$6.7\ 10^{-7}$	$2.3\ 10^{-7}$	$1.2\ 10^{-8}$	$2.8\ 10^{-9}$	$6.2\ 10^{-6}$	$1.7\ 10^{-5}$	$9.9\ 10^{-8}$	$1.9\ 10^{-6}$	$4.4\ 10^{-8}$	$1.6\ 10^{-6}$
Co-60	$3.7\ 10^{-6}$	$1.2\ 10^{-6}$	$6.7\ 10^{-8}$	$1.5\ 10^{-8}$	$3.3\ 10^{-5}$	$9.2\ 10^{-5}$	$5.5\ 10^{-7}$	$1.0\ 10^{-5}$	$2.5\ 10^{-7}$	$8.8\ 10^{-6}$
Cs-134	$1.9\ 10^{-5}$	$1.1\ 10^{-4}$	$6.8\ 10^{-5}$	$5.2\ 10^{-6}$	$3.8\ 10^{-4}$	$1.0\ 10^{-3}$	$1.2\ 10^{-4}$	$2.2\ 10^{-5}$	$5.2\ 10^{-5}$	$1.8\ 10^{-5}$
Cs-137	$1.1\ 10^{-5}$	$6.5\ 10^{-5}$	$4.2\ 10^{-5}$	$3.2\ 10^{-6}$	$2.3\ 10^{-4}$	$2.0\ 10^{-4}$	$7.2\ 10^{-5}$	$1.3\ 10^{-5}$	$3.2\ 10^{-5}$	$1.1\ 10^{-5}$
H-3	$3.1\ 10^{-2}$	$1.8\ 10^{-2}$	$4.5\ 10^{-2}$	$8.9\ 10^{-3}$	$9.9\ 10^{-2}$	$1.1\ 10^{-2}$	$5.4\ 10^{-3}$	$9.8\ 10^{-4}$	$4.3\ 10^{-3}$	$1.5\ 10^{-3}$
I-131	$2.3\ 10^{-3}$	$3.1\ 10^{-3}$	$7.0\ 10^{-4}$	$1.3\ 10^{-4}$	$2.3\ 10^{-2}$	$5.8\ 10^{-2}$	$4.7\ 10^{-4}$	$1.1\ 10^{-4}$	$2.3\ 10^{-4}$	$1.4\ 10^{-4}$
I-133	$8.5\ 10^{-5}$	$1.2\ 10^{-4}$	$2.7\ 10^{-5}$	$5.1\ 10^{-6}$	$8.6\ 10^{-4}$	$1.1\ 10^{-3}$	$2.1\ 10^{-6}$	$4.2\ 10^{-6}$	$5.8\ 10^{-8}$	$5.4\ 10^{-6}$
Kr-85	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Xe-131m	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Xe-133	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Xe-135	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Total	$2.2\ 10^{-1}$	$1.3\ 10^{-1}$	$3.1\ 10^{-1}$	$6.2\ 10^{-2}$	$1.9\ 10^{0}$	$2.7\ 10^{0}$	$4.3\ 10^{-1}$	$7.8\ 10^{-2}$	$4.5\ 10^{-1}$	$1.5\ 10^{-1}$

Table A7.10 continued

Radionuclide	Cloud Beta	Cloud Gamma	Dep Gamma	Inhalation	R 10-suspension	Total
Ar-41	$2.8\ 10^{-4}$	$2.4\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.4\ 10^{-2}$
C-14	$2.7\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.6\ 10^{-1}$	$0.0\ 10^{0}$	$6.4\ 10^{0}$
Co-58	$1.1\ 10^{-10}$	$1.7\ 10^{-7}$	$4.3\ 10^{-5}$	$3.4\ 10^{-6}$	$1.8\ 10^{-9}$	$7.4\ 10^{-5}$
Co-60	$2.4\ 10^{-10}$	$4.7\ 10^{-7}$	$4.2\ 10^{-4}$	$2.5\ 10^{-5}$	$1.8\ 10^{-8}$	$6.0\ 10^{-4}$
Cs-134	$5.7\ 10^{-10}$	$2.4\ 10^{-7}$	$2.0\ 10^{-4}$	$1.3\ 10^{-5}$	$9.0\ 10^{-9}$	$2.0\ 10^{-3}$
Cs-137	$5.1\ 10^{-10}$	$5.6\ 10^{-8}$	$7.3\ 10^{-5}$	$7.9\ 10^{-6}$	$5.9\ 10^{-9}$	$7.6\ 10^{-4}$
H-3	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.8\ 10^{-2}$	$0.0\ 10^{0}$	$2.4\ 10^{-1}$
I-131	$2.0\ 10^{-8}$	$2.4\ 10^{-6}$	$5.8\ 10^{-4}$	$4.4\ 10^{-4}$	$1.4\ 10^{-6}$	$8.8\ 10^{-2}$
I-133	$1.1\ 10^{-8}$	$7.0\ 10^{-7}$	$2.1\ 10^{-5}$	$1.7\ 10^{-5}$	$2.4\ 10^{-8}$	$2.2\ 10^{-3}$
Kr-85	$6.6\ 10^{-4}$	$2.3\ 10^{-4}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$8.9\ 10^{-4}$
Xe-131m	$4.3\ 10^{-6}$	$2.7\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.1\ 10^{-5}$
Xe-133	$6.3\ 10^{-4}$	$2.2\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.3\ 10^{-2}$
Xe-135	$1.2\ 10^{-3}$	$3.9\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$4.0\ 10^{-2}$
Total	$2.8\ 10^{-3}$	$8.6\ 10^{-2}$	$1.3\ 10^{-3}$	$3.8\ 10^{-1}$	$1.4\ 10^{-6}$	$6.8\ 10^{0}$

Table A7.11 Annual effective dose (µSv) to child with generic ingestion rates from short-term atmospheric release from SZC

Radionuclide	Green vegetables	Soft fruit	Potatoes	Carrots	Milk	Milk products	Cow meat	Cow liver	Sheep meat	Sheep liver
Ar-41	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}
C-14	1.1 10^{-1}	1.1 10^{-1}	3.3 10^{-1}	3.7 10^{-2}	2.4 10^{0}	2.7 10^{0}	5.8 10^{-1}	5.8 10^{-2}	3.0 10^{-1}	1.1 10^{-1}
Co-58	6.6 10^{-7}	3.9 10^{-7}	2.5 10^{-8}	3.2 10^{-9}	1.4 10^{-5}	2.9 10^{-5}	2.3 10^{-7}	2.3 10^{-6}	5.0 10^{-8}	2.0 10^{-6}
Co-60	5.1 10^{-6}	3.0 10^{-6}	1.9 10^{-7}	2.4 10^{-8}	1.1 10^{-4}	2.2 10^{-4}	1.8 10^{-6}	1.8 10^{-5}	4.1 10^{-7}	1.5 10^{-5}
Cs-134	5.9 10^{-6}	5.9 10^{-5}	4.5 10^{-5}	1.9 10^{-6}	2.8 10^{-4}	5.7 10^{-4}	8.6 10^{-5}	8.7 10^{-6}	1.9 10^{-5}	7.3 10^{-6}
Cs-137	3.8 10^{-6}	3.8 10^{-5}	2.9 10^{-5}	1.2 10^{-6}	1.8 10^{-4}	1.1 10^{-4}	5.6 10^{-5}	5.6 10^{-6}	1.2 10^{-5}	4.7 10^{-6}
H-3	1.8 10^{-2}	1.8 10^{-2}	5.3 10^{-2}	5.8 10^{-3}	1.3 10^{-1}	1.1 10^{-2}	7.0 10^{-3}	7.0 10^{-4}	2.8 10^{-3}	1.1 10^{-3}
I-131	2.3 10^{-3}	5.5 10^{-3}	1.5 10^{-3}	1.6 10^{-4}	5.4 10^{-2}	1.0 10^{-1}	1.1 10^{-3}	1.4 10^{-4}	2.7 10^{-4}	1.8 10^{-4}
I-133	8.5 10^{-5}	2.0 10^{-4}	5.6 10^{-5}	5.9 10^{-6}	2.0 10^{-3}	1.9 10^{-3}	4.8 10^{-6}	5.3 10^{-6}	6.7 10^{-8}	6.8 10^{-6}
Kr-85	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}
Xe-131m	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}
Xe-133	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}
Xe-135	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}	0.0 10^{0}
Total	1.3 10^{-1}	1.3 10^{-1}	3.8 10^{-1}	4.3 10^{-2}	2.6 10^{0}	2.8 10^{0}	5.9 10^{-1}	5.9 10^{-2}	3.1 10^{-1}	1.2 10^{-1}

Table A7.11 continued

Radionuclide	Cloud Beta	Cloud Gamma	Dep Gamma	Inhalation	R 10-suspension	Total
Ar-41	$2.8\ 10^{-4}$	$2.4\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.4\ 10^{-2}$
C-14	$2.7\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.5\ 10^{-1}$	$0.0\ 10^{0}$	$7.1\ 10^{0}$
Co-58	$1.1\ 10^{-10}$	$1.7\ 10^{-7}$	$4.3\ 10^{-5}$	$3.5\ 10^{-6}$	$1.9\ 10^{-9}$	$9.5\ 10^{-5}$
Co-60	$2.4\ 10^{-10}$	$4.7\ 10^{-7}$	$4.2\ 10^{-4}$	$2.6\ 10^{-5}$	$1.9\ 10^{-8}$	$8.2\ 10^{-4}$
Cs-134	$5.7\ 10^{-10}$	$2.4\ 10^{-7}$	$2.0\ 10^{-4}$	$7.1\ 10^{-6}$	$5.0\ 10^{-9}$	$1.3\ 10^{-3}$
Cs-137	$5.1\ 10^{-10}$	$5.6\ 10^{-8}$	$7.3\ 10^{-5}$	$4.4\ 10^{-6}$	$3.3\ 10^{-9}$	$5.2\ 10^{-4}$
H-3	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.6\ 10^{-2}$	$0.0\ 10^{0}$	$2.6\ 10^{-1}$
I-131	$2.0\ 10^{-8}$	$2.4\ 10^{-6}$	$5.8\ 10^{-4}$	$7.9\ 10^{-4}$	$2.4\ 10^{-6}$	$1.7\ 10^{-1}$
I-133	$1.1\ 10^{-8}$	$7.0\ 10^{-7}$	$2.1\ 10^{-5}$	$3.1\ 10^{-5}$	$4.2\ 10^{-8}$	$4.3\ 10^{-3}$
Kr-85	$6.6\ 10^{-4}$	$2.3\ 10^{-4}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$8.9\ 10^{-4}$
Xe-131m	$4.3\ 10^{-6}$	$2.7\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.1\ 10^{-5}$
Xe-133	$6.3\ 10^{-4}$	$2.2\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.3\ 10^{-2}$
Xe-135	$1.2\ 10^{-3}$	$3.9\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$4.0\ 10^{-2}$
Total	$2.8\ 10^{-3}$	$8.6\ 10^{-2}$	$1.3\ 10^{-3}$	$3.7\ 10^{-1}$	$2.5\ 10^{-6}$	$7.6\ 10^{0}$

Table A7.12 Annual effective dose (μSv) to infant with generic ingestion rates from short-term atmospheric release from SZC

Radionuclide	Green vegetables	Soft fruit	Potatoes	Carrots	Milk	Milk products	Cow meat	Cow liver	Sheep meat	Sheep liver
Ar-41	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
C-14	$7.4\ 10^{-2}$	$1.3\ 10^{-1}$	$1.5\ 10^{-1}$	$7.3\ 10^{-2}$	$6.4\ 10^{0}$	$5.4\ 10^{0}$	$2.3\ 10^{-1}$	$3.9\ 10^{-2}$	$1.2\ 10^{-1}$	$7.6\ 10^{-2}$
Co-58	$5.7\ 10^{-7}$	$6.1\ 10^{-7}$	$1.5\ 10^{-8}$	$8.2\ 10^{-9}$	$4.9\ 10^{-5}$	$7.5\ 10^{-5}$	$1.2\ 10^{-7}$	$2.0\ 10^{-6}$	$2.6\ 10^{-8}$	$1.7\ 10^{-6}$
Co-60	$4.1\ 10^{-6}$	$4.4\ 10^{-6}$	$1.1\ 10^{-7}$	$5.9\ 10^{-8}$	$3.5\ 10^{-4}$	$5.5\ 10^{-4}$	$8.7\ 10^{-7}$	$1.5\ 10^{-5}$	$2.0\ 10^{-7}$	$1.3\ 10^{-5}$
Cs-134	$2.2\ 10^{-6}$	$4.0\ 10^{-5}$	$1.1\ 10^{-5}$	$2.2\ 10^{-6}$	$4.2\ 10^{-4}$	$6.5\ 10^{-4}$	$2.0\ 10^{-5}$	$3.3\ 10^{-6}$	$4.4\ 10^{-6}$	$2.8\ 10^{-6}$
Cs-137	$1.5\ 10^{-6}$	$2.7\ 10^{-5}$	$7.7\ 10^{-6}$	$1.5\ 10^{-6}$	$2.8\ 10^{-4}$	$1.4\ 10^{-4}$	$1.3\ 10^{-5}$	$2.2\ 10^{-6}$	$3.0\ 10^{-6}$	$1.9\ 10^{-6}$
H-3	$1.2\ 10^{-2}$	$2.2\ 10^{-2}$	$2.4\ 10^{-2}$	$1.2\ 10^{-2}$	$3.6\ 10^{-1}$	$2.2\ 10^{-2}$	$2.9\ 10^{-3}$	$4.9\ 10^{-4}$	$1.2\ 10^{-3}$	$7.4\ 10^{-4}$
I-131	$2.6\ 10^{-3}$	$1.1\ 10^{-2}$	$1.1\ 10^{-3}$	$5.5\ 10^{-4}$	$2.5\ 10^{-1}$	$3.5\ 10^{-1}$	$7.7\ 10^{-4}$	$1.7\ 10^{-4}$	$1.9\ 10^{-4}$	$2.1\ 10^{-4}$
I-133	$1.2\ 10^{-4}$	$5.4\ 10^{-4}$	$5.4\ 10^{-5}$	$2.6\ 10^{-5}$	$1.2\ 10^{-2}$	$8.2\ 10^{-3}$	$4.2\ 10^{-6}$	$7.8\ 10^{-6}$	$5.9\ 10^{-8}$	$1.0\ 10^{-5}$
Kr-85	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Xe-131m	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Xe-133	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Xe-135	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$
Total	$8.9\ 10^{-2}$	$1.7\ 10^{-1}$	$1.7\ 10^{-1}$	$8.6\ 10^{-2}$	$7.0\ 10^{0}$	$5.8\ 10^{0}$	$2.4\ 10^{-1}$	$3.9\ 10^{-2}$	$1.2\ 10^{-1}$	$7.7\ 10^{-2}$

Table A7.12 continued

Radionuclide	Cloud Beta	Cloud Gamma	Dep Gamma	Inhalation	R 10-suspension	Total
Ar-41	$2.8\ 10^{-4}$	$2.4\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.4\ 10^{-2}$
C-14	$2.7\ 10^{-6}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.7\ 10^{-1}$	$0.0\ 10^{0}$	$1.3\ 10^{1}$
Co-58	$1.1\ 10^{-10}$	$1.7\ 10^{-7}$	$4.3\ 10^{-5}$	$3.3\ 10^{-6}$	$1.7\ 10^{-9}$	$1.7\ 10^{-4}$
Co-60	$2.4\ 10^{-10}$	$4.7\ 10^{-7}$	$4.2\ 10^{-4}$	$2.0\ 10^{-5}$	$1.5\ 10^{-8}$	$1.4\ 10^{-3}$
Cs-134	$5.7\ 10^{-10}$	$2.4\ 10^{-7}$	$2.0\ 10^{-4}$	$3.4\ 10^{-6}$	$2.4\ 10^{-9}$	$1.4\ 10^{-3}$
Cs-137	$5.1\ 10^{-10}$	$5.6\ 10^{-8}$	$7.3\ 10^{-5}$	$2.2\ 10^{-6}$	$1.7\ 10^{-9}$	$5.6\ 10^{-4}$
H-3	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$1.2\ 10^{-2}$	$0.0\ 10^{0}$	$4.7\ 10^{-1}$
I-131	$2.0\ 10^{-8}$	$2.4\ 10^{-6}$	$5.8\ 10^{-4}$	$1.0\ 10^{-3}$	$3.2\ 10^{-6}$	$6.2\ 10^{-1}$
I-133	$1.1\ 10^{-8}$	$7.0\ 10^{-7}$	$2.1\ 10^{-5}$	$5.0\ 10^{-5}$	$6.8\ 10^{-8}$	$2.1\ 10^{-2}$
Kr-85	$6.6\ 10^{-4}$	$2.3\ 10^{-4}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$8.9\ 10^{-4}$
Xe-131m	$4.3\ 10^{-6}$	$2.7\ 10^{-5}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$3.1\ 10^{-5}$
Xe-133	$6.3\ 10^{-4}$	$2.2\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$2.3\ 10^{-2}$
Xe-135	$1.2\ 10^{-3}$	$3.9\ 10^{-2}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$0.0\ 10^{0}$	$4.0\ 10^{-2}$
Total	$2.8\ 10^{-3}$	$8.6\ 10^{-2}$	$1.3\ 10^{-3}$	$2.9\ 10^{-1}$	$3.3\ 10^{-6}$	$1.4\ 10^{1}$

Table A7.13 Peak activity concentrations in foodstuffs following a short-term release to atmosphere at the proposed annual limits (Bq kg^{-1})

Radionclide	Green vegetables	Soft fruit	Potatoes	Carrots	Milk	Cow meat	Cow liver	Sheep meat	Sheep liver
Co-60	3.42 10^{-2}	3.54 10^{-4}	5.98 10^{-6}	5.98 10^{-6}	2.86 10^{-4}	1.49 10^{-5}	1.49 10^{-3}	2.37 10^{-5}	2.08 10^{-2}
Co-58 *	2.95 10^{-2}	3.05 10^{-4}	5.16 10^{-6}	5.16 10^{-6}	2.47 10^{-4}	1.29 10^{-5}	1.29 10^{-3}	2.05 10^{-5}	1.79 10^{-2}
I-133	1.56 10^{0}	3.91 10^{-8}	9.23 10^{-9}	9.23 10^{-9}	7.26 10^{-2}	2.13 10^{-2}	2.13 10^{-2}	6.95 10^{-3}	6.95 10^{-4}
I-131	8.40 10^{0}	1.71 10^{-1}	4.79 10^{-2}	4.79 10^{-2}	2.00 10^{0}	6.55 10^{-1}	6.55 10^{-1}	5.57 10^{-1}	5.57 10^{-1}
Cs-137	2.49 10-2	6.74 10-3	1.87 10-3	1.89 10-3	6.01 10-3	1.04 10-2	1.04 10-2	1.93 10-2	1.93 10-2
Cs-134	2.64 10-2	6.98 10-3	1.95 10-3	1.96 10-3	6.36 10-3	1.08 10-2	1.08 10-2	2.00 10-2	2.00 10-2

* uses Co-60 values as not included in PACE dataset

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Appendix 8 Additional data for collective doses

Collective doses were calculated for expected discharges to atmosphere and liquid discharges from SZC using PC-CREAM 08. In general, the models in PC-CREAM 08 were run in the same way as for the calculation of individual doses. This appendix summarises input data specific to the collective dose calculations.

Table A8.1 Input data for the collective dose calculation - atmospheric dispersion

Parameter	Value
Effective release height (m)	20 (only one representative stack is considered)
Integration time (y)	500
Discharges	See Table 1
Exposure population	UK, Europe, World
Delay times	PC-CREAM 08 defaults (these are for commercial production)
Occupancy indoors	90%
Indoor shielding factors	Cloud gamma 0.2 Deposited gamma 0.1 Cloud beta 1.0 Deposited beta 1.0 Inhalation 1.0
Inhalation rates (m^3/y)	8.1 10^3
Meteorological data	The same as that used for individual dose assessment, see Appendix 3
Spatial datasets	Population and agricultural production data included in PC-CREAM 08 (version 1.5.1.92/2.0.0)

Table A8.2 Input data for the collective dose calculation - marine dispersion

Parameter	Value
Local marine compartment	Default compartment for Sizewell
Discharges	See Table 4
Beach occupancy near site (person h/y/m)	50
Seafood catch data	Default data for fish, crustaceans and molluscs included in PC-CREAM 08 (version 1.5.1.92/2.0.0)

Table A8.3 Collective doses in person Sv from discharges to atmosphere

Population/ Radionuclide	UK First pass	UK Global	UK Total	EU First pass	EU Global	EU Total	World Global	World Total*
Ar-41	$3.9\ 10^{-5}$	$0.0\ 10^{0}$	$3.9\ 10^{-5}$	$5.2\ 10^{-5}$	$0.0\ 10^{0}$	$5.2\ 10^{-5}$	$0.0\ 10^{0}$	$5.2\ 10^{-5}$
C-14	$2.8\ 10^{-1}$	$1.5\ 10^{-1}$	$4.2\ 10^{-1}$	$2.5\ 10^{0}$	$1.1\ 10^{0}$	$3.6\ 10^{0}$	$2.5\ 10^{1}$	$2.7\ 10^{1}$
Co-58	$1.0\ 10^{-6}$	$0.0\ 10^{0}$	$1.0\ 10^{-6}$	$2.8\ 10^{-6}$	$0.0\ 10^{0}$	$2.8\ 10^{-6}$	$0.0\ 10^{0}$	$2.8\ 10^{-6}$
Co-60	$3.7\ 10^{-5}$	$0.0\ 10^{0}$	$3.7\ 10^{-5}$	$1.0\ 10^{-4}$	$0.0\ 10^{0}$	$1.0\ 10^{-4}$	$0.0\ 10^{0}$	$1.0\ 10^{-4}$
Cs-134	$6.1\ 10^{-5}$	$0.0\ 10^{0}$	$6.1\ 10^{-5}$	$3.4\ 10^{-4}$	$0.0\ 10^{0}$	$3.4\ 10^{-4}$	$0.0\ 10^{0}$	$3.4\ 10^{-4}$
Cs-137	$5.5\ 10^{-5}$	$0.0\ 10^{0}$	$5.5\ 10^{-5}$	$2.8\ 10^{-4}$	$0.0\ 10^{0}$	$2.8\ 10^{-4}$	$0.0\ 10^{0}$	$2.8\ 10^{-4}$
H-3	$3.8\ 10^{-3}$	$1.2\ 10^{-5}$	$3.8\ 10^{-3}$	$1.9\ 10^{-2}$	$8.9\ 10^{-5}$	$1.9\ 10^{-2}$	$2.0\ 10^{-3}$	$2.1\ 10^{-2}$
I-131	$1.5\ 10^{-4}$	$0.0\ 10^{0}$	$1.5\ 10^{-4}$	$1.7\ 10^{-4}$	$0.0\ 10^{0}$	$1.7\ 10^{-4}$	$0.0\ 10^{0}$	$1.7\ 10\text{-}^{4}$
I-133	$1.3\ 10^{-6}$	$0.0\ 10^{0}$	$1.3\ 10^{-6}$	$2.1\ 10^{-6}$	$0.0\ 10^{0}$	$2.1\ 10^{-6}$	$0.0\ 10^{0}$	$2.1\ 10^{-6}$
Kr-85	$2.0\ 10^{-5}$	$9.6\ 10^{-6}$	$2.9\ 10^{-5}$	$9.2\ 10^{-5}$	$7.4\ 10^{-5}$	$1.7\ 10^{-4}$	$1.6\ 10^{-3}$	$1.7\ 10^{-3}$
Xe-131m	$9.7\ 10^{-11}$	$0.0\ 10^{0}$	$9.7\ 10^{-11}$	$5.9\ 10^{-10}$	$0.0\ 10^{0}$	$5.9\ 10^{-10}$	$0.0\ 10^{0}$	$5.9\ 10^{-10}$
Xe-133	$1.6\ 10^{-7}$	$0.0\ 10^{0}$	$1.6\ 10^{-7}$	$8.9\ 10^{-7}$	$0.0\ 10^{0}$	$8.9\ 10^{-7}$	$0.0\ 10^{0}$	$8.9\ 10^{-7}$
Xe-135	$2.3\ 10^{-4}$	$0.0\ 10^{0}$	$2.3\ 10^{-4}$	$4.8\ 10^{-4}$	$0.0\ 10^{0}$	$4.8\ 10^{-4}$	$0.0\ 10^{0}$	$4.8\ 10^{-4}$
Total	$2.8\ 10^{-1}$	$1.5\ 10^{-1}$	$4.3\ 10^{-1}$	$2.5\ 10^{0}$	$1.1\ 10^{0}$	$3.6\ 10^{0}$	$2.5\ 10^{1}$	$2.7\ 10^{1}$

*First pass collective dose calculations are not performed for releases to atmosphere, as such the World total is the sum of the World Global Circulation and the EU First Pass data for each radionuclide.

Table A8.4 Collective doses in person Sv from aqueous discharges from Sizewell C

Population/ Radionuclide	UK First pass	UK Global	UK Total	EU First pass	EU Global	EU Total
Ag-110m	$8.3\ 10^{-5}$	$0.0\ 10^{0}$	$8.3\ 10^{-5}$	$5.3\ 10^{-4}$	$0.0\ 10^{0}$	$5.3\ 10^{-4}$
C-14	$2.2\ 10^{-2}$	$1.3\ 10^{-2}$	$3.5\ 10^{-2}$	$1.3\ 10^{-1}$	$7.6\ 10^{-2}$	$2.1\ 10^{-1}$
Co-58	$3.0\ 10^{-6}$	$0.0\ 10^{0}$	$3.0\ 10^{-6}$	$2.0\ 10^{-5}$	$0.0\ 10^{0}$	$2.0\ 10^{-5}$
Co-60	$3.9\ 10^{-5}$	$0.0\ 10^{0}$	$3.9\ 10^{-5}$	$2.4\ 10^{-4}$	$0.0\ 10^{0}$	$2.4\ 10^{-4}$
Cr-51	$1.3\ 10^{-9}$	$0.0\ 10^{0}$	$1.3\ 10^{-9}$	$8.1\ 10^{-9}$	$0.0\ 10^{0}$	$8.1\ 10^{-9}$
Cs-134	$8.3\ 10^{-6}$	$0.0\ 10^{0}$	$8.3\ 10^{-6}$	$5.0\ 10^{-5}$	$0.0\ 10^{0}$	$5.0\ 10^{-5}$

Population/ Radionuclide	UK First pass	UK Global	UK Total	EU First pass	EU Global	EU Total
Cs-137	$1.5\ 10^{-5}$	$0.0\ 10^{0}$	$1.5\ 10^{-5}$	$8.7\ 10^{-5}$	$0.0\ 10^{0}$	$8.7\ 10^{-5}$
H-3	$3.4\ 10^{-5}$	$4.0\ 10^{-5}$	$7.5\ 10^{-5}$	$2.0\ 10^{-4}$	$2.4\ 10^{-4}$	$4.5\ 10^{-4}$
I-131	$1.2\ 10^{-8}$	$0.0\ 10^{0}$	$1.2\ 10^{-8}$	$7.7\ 10^{-8}$	$0.0\ 10^{0}$	$7.7\ 10^{-8}$
Xe-131m	$3.9\ 10^{-15}$	$0.0\ 10^{0}$	$3.9\ 10^{-15}$	$3.9\ 10^{-15}$	$0.0\ 10^{0}$	$3.9\ 10^{-15}$
Mn-54	$3.6\ 10^{-6}$	$0.0\ 10^{0}$	$3.6\ 10^{-6}$	$2.3\ 10^{-5}$	$0.0\ 10^{0}$	$2.3\ 10^{-5}$
Ni-63	$8.9\ 10^{-7}$	$0.0\ 10^{0}$	$8.9\ 10^{-7}$	$5.8\ 10^{-6}$	$0.0\ 10^{0}$	$5.8\ 10^{-6}$
Sb-124	$8.4\ 10^{-7}$	$0.0\ 10^{0}$	$8.4\ 10^{-7}$	$6.0\ 10^{-6}$	$0.0\ 10^{0}$	$6.0\ 10^{-6}$
Sb-125	$2.9\ 10^{-6}$	$0.0\ 10^{0}$	$2.9\ 10^{-6}$	$1.7\ 10^{-5}$	$0.0\ 10^{0}$	$1.7\ 10^{-5}$
Te-125m	$7.4\ 10^{-6}$	$0.0\ 10^{0}$	$7.4\ 10^{-6}$	$4.4\ 10^{-5}$	$0.0\ 10^{0}$	$4.4\ 10^{-5}$
Te-123m	$2.5\ 10^{-6}$	$0.0\ 10^{0}$	$2.5\ 10^{-6}$	$1.7\ 10^{-5}$	$0.0\ 10^{0}$	$1.7\ 10^{-5}$
Te-123	$5.0\ 10^{-19}$	$0.0\ 10^{0}$	$5.0\ 10^{-19}$	$2.8\ 10^{-18}$	$0.0\ 10^{0}$	$2.8\ 10^{-18}$
Total	$2.2\ 10^{-2}$	$1.3\ 10^{-2}$	$3.5\ 10^{-2}$	$1.3\ 10^{-1}$	$7.6\ 10^{-2}$	$2.1\ 10^{-1}$

Table 8.4 continued

Population/ Radionuclide	World First pass	World Global	World Total
Ag-110m	$6.1\ 10^{-4}$	$0.0\ 10^{0}$	$6.1\ 10^{-4}$
C-14	$2.3\ 10^{-1}$	$2.1\ 10^{0}$	$2.3\ 10^{0}$
Co-58	$2.5\ 10^{-5}$	$0.0\ 10^{0}$	$2.5\ 10^{-5}$
Co-60	$2.9\ 10^{-4}$	$0.0\ 10^{0}$	$2.9\ 10^{-4}$
Cr-51	$9.7\ 10^{-9}$	$0.0\ 10^{0}$	$9.7\ 10^{-9}$
Cs-134	$8.4\ 10^{-5}$	$0.0\ 10^{0}$	$8.4\ 10^{-5}$
Cs-137	$1.6\ 10^{-4}$	$0.0\ 10^{0}$	$1.6\ 10^{-4}$
H-3	$3.2\ 10^{-4}$	$6.8\ 10^{-3}$	$7.1\ 10^{-3}$
I-131	$9.9\ 10^{-8}$	$0.0\ 10^{0}$	$9.9\ 10^{-8}$
Xe-131m	$3.9\ 10^{-15}$	$0.0\ 10^{0}$	$3.9\ 10^{-15}$
Mn-54	$2.4\ 10^{-5}$	$0.0\ 10^{0}$	$2.4\ 10^{-5}$
Ni-63	$8.0\ 10^{-6}$	$0.0\ 10^{0}$	$8.0\ 10^{-6}$
Sb-124	$1.0\ 10^{-5}$	$0.0\ 10^{0}$	$1.0\ 10^{-5}$
Sb-125	$3.1\ 10^{-5}$	$0.0\ 10^{0}$	$3.1\ 10^{-5}$
Te-125m	$6.9\ 10^{-5}$	$0.0\ 10^{0}$	$6.9\ 10^{-5}$
Te-123m	$2.3\ 10^{-5}$	$0.0\ 10^{0}$	$2.3\ 10^{-5}$
Te-123	$5.5\ 10^{-18}$	$0.0\ 10^{0}$	$5.5\ 10^{-18}$

Population/ Radionuclide	World First pass	World Global	World Total
Total	$2.2\ 10^{-1}$	$2.1\ 10^{0}$	$2.3\ 10^{0}$

Appendix 9 Doses to representative person

In this study habits profiles were taken from the 2015 CEFAS survey (Garrod et al, 2016) conducted around the Sizewell site. Each habits profile was used as a CRP and annual doses arising in the 60th year as a consequence of expected liquid discharges and discharges to atmosphere from SZC were calculated for each using PC-CREAM 08. These doses were reviewed to identify the RP for SZC. Once the RP had been identified doses to this individual were also calculated for direct radiation from SZC (using NNB GenCo (SZC) methodology (NNB GenCo (SZC), 2019)) and expected short-term releases from SZC (using ADMS and guidance from NDAWG (NDAWG, 2020)). The resulting total dose can be compared to the dose constraint for a single source (300 µSv) as advised in the dose assessment principles document (Environment Agency et al, 2012).

Contributions to the dose of the RP were then calculated for future expected discharges from SZA and SZB using PC-CREAM 08. The total dose from expected discharges from SZC, SZA and SZB, but excluding direct radiation, can be compared with the dose constraint for a single site (500 µSv). These are presented in Table 10.

Finally, doses received by the RP as a consequence of historical discharges from SZA and SZB were assessed using values from RIFE 23, RIFE 24 and RIFE 25 (Environment Agency et al, 2018), (Environment Agency et al, 2019) and (Environment Agency et al, 2020). The doses from these reports are 2.1 10^{1} µSv, 2.6 10^{1} µSv and 1.0 10^{1} µSv, respectively, and are based largely on measurements of environmental radioactivity taken around the site. The average of these doses, 1.9 10^{1} µSv, was used in the dose assessment. Doses from historical discharges can be combined with doses from future discharges and direct radiation to provide an estimate of the total dose from the Sizewell site. The total dose for the Sizewell site includes expected and historic discharges, direct radiation and short-term releases. This dose can be compared to the dose limit (1000 µSv). The results are shown in Table 11.

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