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CHAPTER 7: POTENTIAL RADIOLOGICAL IMPACT ON THE PUBLIC AND THE ENVIRONMENT

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Author declaration:

I declare that appropriate diligence and quality assurance was applied in the compilation of this report. As such I am confident in the results here described and the conclusions drawn.

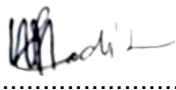


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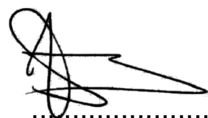
I declare that this report has undergone independent peer review by myself, that comments were addressed to my satisfaction, and that as such, it is considered fit for publication.



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AMENDMENT RECORD			
Rev	Draft	Date	Amendments
0	9	03/05/2012	- Changes following nuclear engineering review comments. - Exclusion of design basis accidents. - Changes following peer reviewer and technical writer comments and SRK final review.
0	10	12/06/2013	Changes in dose assessment methodology.
0	11	04/01/2014	- Changes to address Eskom comments. - Provision of additional information to clarify concepts.
0	12	30/01/2014	Minor changes in sentence construction/addition following a meeting with Eskom
0	13	26/2/2014	Addition of information to the conclusions section and further editorial changes
0a	1	28/11/2024	- Update in response to NNR comments. The main changes included in the update are: - changes to site meteorological input data to the dose assessment code PC-CREAM 08 - public dose calculation for a site representative person that is defined based on the latest habits survey (2024) - a change in the methodology to calculate dose for short term airborne releases during minor operational occurrences.
0a	2	23/1/2025	Responses to Eskom review comments
0b	1	23/09/2025	Update in response to NNR comments. The main change is updating the Radiological Impact on non-human biota using ERICA Tool Version 2.0
0c		04/03/2026	- Update in response to NNR comments. - The header for this document indicates that the document is a “draft”. Eskom should submit the final revision for NNR review - Addressing the misalignment of a copyright description, consistent with the revision history appearing at the bottom of each page, throughout the document - Justifying the exclusion of the Anticipated Operational Occurrences (AOO) from the dose assessment - Providing clarity on: - the methodology and justifications thereof, used for the construction of the enveloping airborne and liquid source terms - the meaning of maximum radionuclide specific source term. - The methodology used to scale up the radionuclide specific source term to represent 33000MWth

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AMENDMENT RECORD			
Rev	Draft	Date	Amendments
0d		24/06/2026	- Addressing NNR comment by providing clarity on: a) the methodology and justifications thereof, used for the construction of the enveloping airborne and liquid source terms b) the meaning of maximum radionuclide specific source term. c) The methodology used to scale up the radionuclide specific source term to represent 33000MWth

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Executive Summary

The construction of nuclear installations consisting of several new nuclear power stations (NNPS) at the site is envisaged. The planned capacity is 9 900 to 13 200 MW_{th} and an eventual total site capacity of up to a maximum power of approximately 33 000 MW_{th}, assuming a nominal 33 per cent efficiency of the reactors of the NNPS. The number and design of the reactors are still to be determined, but they will be of the Pressurised Water Reactor (PWR) type.

A prospective radiological impact on the public and the environment (PRIPE) was carried out based on conservative and enveloping discharges of airborne and liquid radioactivity during normal operation. The assessment includes minor occurrences that may result in a higher impact over a short period of time when compared to the impact of normal continuous discharges. An estimate of direct external radiation from the NNPS structures at the site boundary is included in the impact assessment. The result of the radiological impact assessment is presented as the annual dose to a person representative of the public based on latest survey data of habits of members of the public in the vicinity of the site.

No vendor has yet been appointed and detailed design and power generation of the NNPS remain undefined except that PWR GEN III technology will be selected by Eskom. NNPS design information of four representative GEN III technologies was used to construct radioactive source terms of operational discharges to the environment. Bounding source terms were derived for 33 000 MW_{th} power operation and radioactivity build-up in the environment after 60 years of operation is included in the dose assessment. The dose assessment is based on conservative assumptions for the purpose of the initial licensing stage and to demonstrate that regulatory criteria of the National Nuclear Regulator (NNR) in respect of ionising dose of members of the public can be met. Once a specific NNPS is selected, a detailed description of all systems of the NNPS and its layout on the site will be presented and the public dose re-assessed.

The annual dose to a member of the public was calculated using the most recent habits data of people living and working in areas adjacent to the site where radiological exposure can occur through various exposure pathways involving food consumption, external radiation and inhalation of radioactivity discharged from the proposed NNPS. The results are summarised and compared to a dose constraint of 250 µSv/y:

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Annual Dose to the Thyspunt Site Representative Person

1. Normal operation continuous discharges ($\mu\text{Sv/y}$)	164.85
2. Contingency discharges during minor occurrences ($\mu\text{Sv/y}$)	6.17
3. Direct radiation from NNPS buildings ($\mu\text{Sv/y}$)	0.50
Total representative person dose: $\mu\text{Sv/y}$	171.52

Interest in the radiological protection of non-human biota from human activities has greatly increased since the Chernobyl accident took place. The International Commission on Radiological Protection (ICRP) provided guidance in respect of various means of assessing and managing human environmental impacts. Although there are no ICRP nor NNR 'dose limits' with respect to environmental protection, the ICRP provides advice regarding those aspects or features of different environments that are likely to be of concern under different radiation exposure situations. A screening dose rate assessment was done for non-human biota based on the NNPS source terms developed for NNPS discharges. It is concluded that the liquid and airborne discharges from the proposed NNPS are unlikely to pose a radiological risk.

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7 POTENTIAL RADIOLOGICAL IMPACT ON THE PUBLIC AND THE ENVIRONMENT

7.1 Purpose and Scope

The purpose of this chapter is to demonstrate that the annual public dose limit of 1 mSv/y and a nuclear site dose constraint of 250 μ Sv/y defined in the National Nuclear Regulator (NNR) regulations can be met (DME, 2006).

The radiological safety assessment is carried out for off-site ionising radiation dose by the proposed nuclear installation(s) consisting of a new nuclear power station (NNPS) that involves:

- continuous airborne and liquid radioactive discharges – It is assumed that these discharges continue for 60 years (the planned operational life of the NNPS).
- short-term contingency discharges that result from minor operational occurrences that can be kept under control;
- direct radiation from the NNPS structures.

Apart from the dose assessment for humans, a screening dose assessment is also performed of the potential radiological impact on non-human species.

7.2 Regulatory Framework

The description of the planned activities on the site was developed based on the current national legal and regulatory framework presented in **Chapter 2** (Legal and Regulatory Basis) and more specifically:

- the National Nuclear Regulator Act (Republic of South Africa, 1999) Section 2 (1)(a)) of the Act applies to the siting, design, construction, operation, decontamination, decommissioning and closure of any nuclear installation.
- R.927: The Regulations on Licensing of Sites for New Nuclear Installations (DoE, 2011) - Regulation 5(2)) requires the following: ‘A statement as to the proposed use of the site in terms of the range of technologies and plant designs being considered for the nuclear installation(s) and use on the site, including where appropriate the maximum thermal power, general design characteristics such as the engineered safety features of the nuclear installation(s) included as safety measures against the hazardous consequences of postulated events, and the layout on the site.’
- R.388: Regulations in Terms of Section 36, Read with Section 47 of the Act (DME, 2006), Sections 2.4 Licensing and 3.3 Prior Safety Assessment.

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The above Act and regulations are supported by the following requirements and guideline documents that have relevance to PRIPE:

- RD-0024, Requirements on Risk Assessment and Compliance with Principal Safety Criteria for Nuclear Installations (NNR, 2008a);
- RD-0034, Quality and Safety Management Requirements for Nuclear Installations (NNR, 2008b);
- RG-0011, Interim Guidance on the Siting of Nuclear Facilities (NNR, 2016a);
- RG-0016, Guidance on the Verification and Validation of Evaluation and Calculation Models used in Safety and Design Analyses (NNR, 2016b);
- RG-0019, Guidance on the Safety Assessments of Nuclear Facilities (NNR, 2018).

7.3 Regulatory Dose Limits and Dose Constraints

Regulations in (DME, 2006) specify an annual effective dose limit from all authorised actions of 1 mSv/y applicable to members of the public. To ensure that the limit is not exceeded, dose constraints are also specified for individual sources. For South Africa, a dose constraint of 250 μ Sv/y is specified. For the purpose of this radiological impact assessment, the site with an NNPS consisting of several reactor units generating 33 000 MW_{th} is considered as a single source. The annual radiation dose for a member of the public must be shown not to exceed the dose constraint equal to 250 μ Sv/y.

There are no regulatory dose limit and dose constraint values applicable to non-human biota. The results of the screening assessment in this report are based on the guidance provided in (ICRP, 2007).

7.4 Public Dose Assessment Framework and Methods

7.4.1 Overview

The radioactive discharges during normal operation are based on a subset of NNPS technologies considered to be representative of an advanced GEN III NNPS. The source terms describing the environmental discharge are defined in **Appendix 7.3**.

A dose assessment was carried out for exposure pathways that are illustrated in **Figure 7.1** and **Figure 7.2**.

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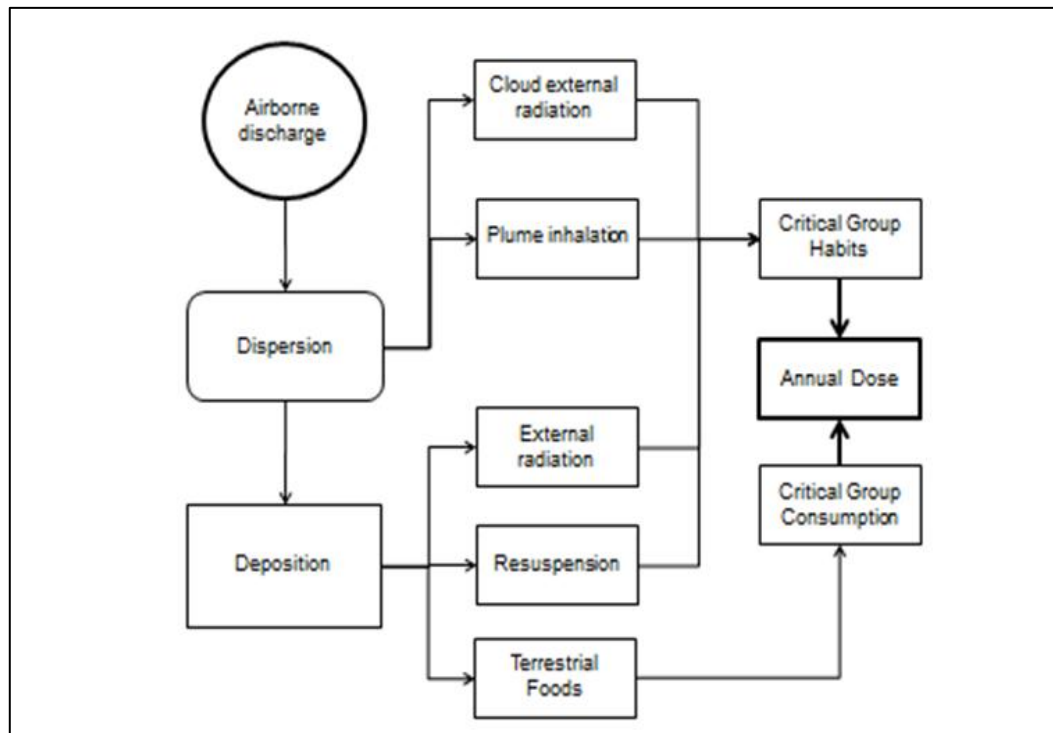


Figure 7.1: Dose Assessment Framework for Airborne Discharges

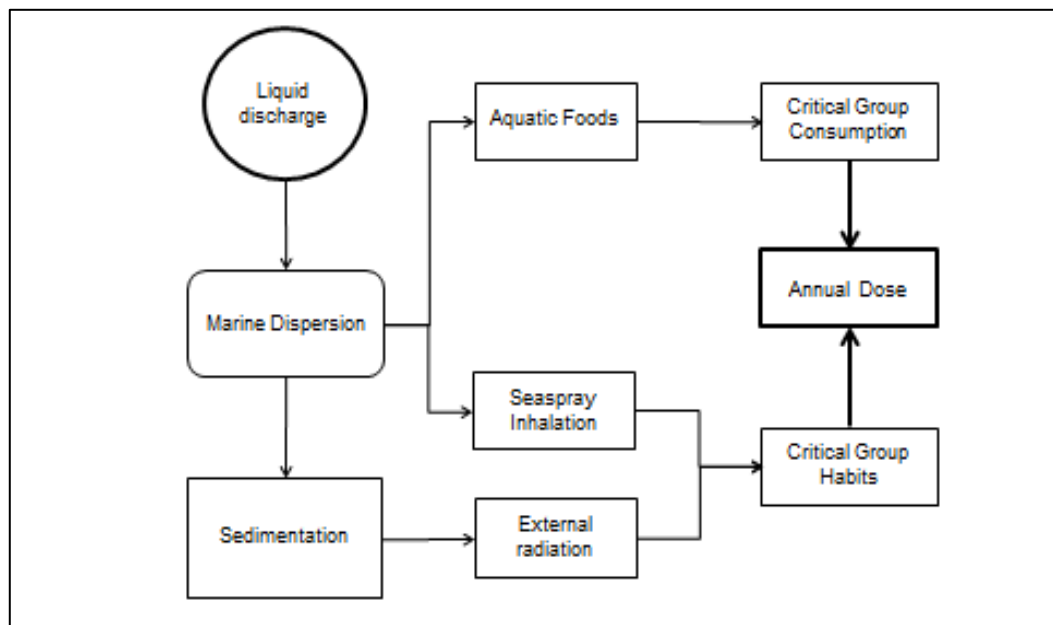


Figure 7.2: Dose Assessment Framework for Liquid Discharges

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The dose assessment for the site is a prospective assessment. A number of different methods and codes are available for estimating annual dose (IAEA, 2017). These methods range from deterministic calculations to more complex probabilistic techniques. A deterministic approach based on conservative assumptions is followed for the site. It provides a bounding assessment of dose based on conservative assumptions that demonstrates compliance with the regulatory dose constraint of 250 $\mu\text{Sv/y}$ (DME, 2006).

A dose assessment based on more realistic assumptions to demonstrate optimisation of radiological protection as part of the ALARA (As Low As Reasonably Achievable) principle requires detailed design information of the NNPS to be selected and built (IAEA, 2011). It forms part of the Safety Analysis Report (SAR) typically prepared for the construction licensing phase. The more realistic assumptions should result in a lower annual dose to the public when compared to the results reported in this site assessment. In the current site assessment, for example, the atmospheric discharges are assumed to be at a height of 10 m. In a real situation, the discharge will be at a typical height of 40 m or more, equal to the design height of the NNPS stacks. This will result in lower atmospheric concentrations in the public domain and therefore a lower radiological impact.

7.4.2 Dose Assessment Framework

7.4.2.1 Exposure Pathways

The public dose assessment is based on the results of a habits survey carried out in the site vicinity that is potentially impacted by normal NNPS operations that could result in public exposure. It is referred to as the Potential Impact Area (PIA) (PSI, 2024). The habits survey provided information to construct a site representative person. The representative person is a construct of an individual with characteristics that reflect those of the group of people in the PIA that receives the highest annual dose. The representative person is equivalent to an “average member of the Critical Group” (ICRP, 2005). Information on the Thyspunt site representative person is provided in **Subsection 7.9**.

The exposure pathways assessed to determine the representative person dose are included in **Table 7.1**. These exposure pathways are described in detail in the Thyspunt habits survey report that should be read with this chapter (PSI, 2024).

All potential exposure pathways are illustrated in **Figure 7.3** of which some are not included in the dose assessment because of their trivial exposure potential. External radiation from liquid discharges when swimming in the sea makes an insignificant contribution to the annual dose. The radioactivity concentrations of Co-60 in seawater and beach sediment, for example, can be compared. The concentration in seawater in the local marine compartment was calculated and is approximately 0.005 Bq/l. This activity can be compared to the approximately 7 Bq/kg of beach sand. The different

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radioactivity concentrations for the two environmental media indicate that the external radiation dose as a result of normally longer time spent on the beach is much greater than time spent swimming in the sea. Accidental ingestion of seawater is also negligible considering the low radionuclide concentrations and low volumes of accidental ingestion.

Table 7.1: Exposure Pathways Assessed

Atmospheric Exposure Pathways	Marine Exposure Pathways
Inhalation of airborne radionuclides	Inhalation of radionuclides in sea spray from the local marine compartment
External gamma dose from airborne radionuclides	External gamma dose from radionuclides in sediment (beach sand at edge of the local marine compartment)
External beta dose from airborne radionuclides	External beta dose from radionuclides in sediment
External gamma dose from deposited radionuclides	External gamma dose from radionuclides on fishing gear
Inhalation from re-suspended radionuclides	Consumption of radionuclides in fish, molluscs, crustaceans and seaweed.
Consumption of radionuclides in beef, cattle liver, cow milk, mutton, sheep liver, green vegetables, root vegetables, fruit, and grain	—

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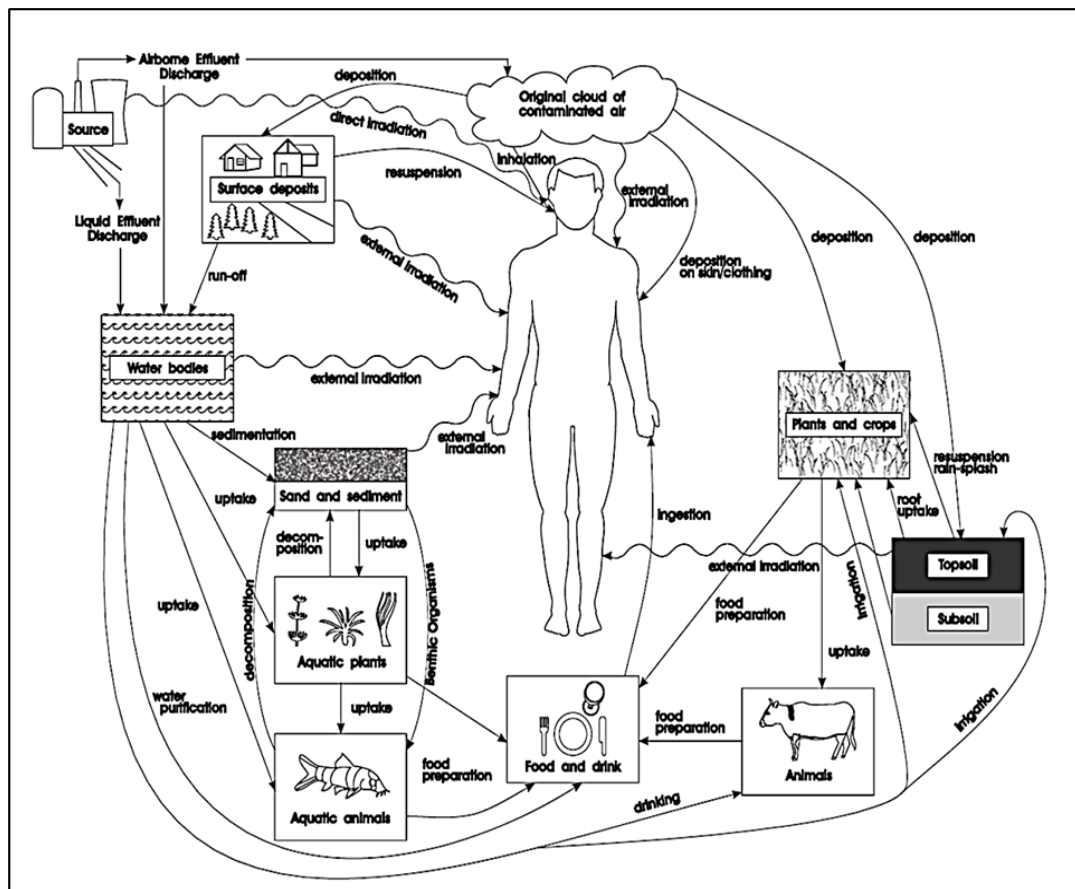


Figure 7.3: NNPS Potential Exposure Pathways

Consumption of surface water in the PIA is not included as an exposure pathway. It could be an important pathway when an NNPS discharge liquid effluent to freshwater bodies, e.g. nuclear facilities located at river sites such as in Europe and in the United States.

Contamination of groundwater resources is also assumed to be an insignificant exposure pathway when compared to other pathways. Following the severe accident of Chernobyl, for example, findings in respect of water resources showed that activity concentrations of soluble radionuclides measured in drinking water made a negligible dose contribution when compared to that associated with the intake of food (IAEA, 2006). Drinking water contributed approximately 1 per cent to the dose in some of the worst affected areas compared to external radiation from soil (50 per cent) and food ingestion (24 per cent). Short-lived radionuclides normally do not affect groundwater supplies, because groundwater residence times are much longer than their physical decay time. In most of the studied area at Chernobyl, the activity concentration in groundwater was significantly lower than in most river and lake systems. Radionuclides in irrigation water did not add significant to radioactivity in crops in comparison with that which had been initially deposited in atmospheric fallout and subsequently taken up in situ from the soil.

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Groundwater flow at the site is towards the ocean/coast. Therefore, radioactive effluent resulting from an accident spill, for example, is towards the ocean/coast. Modelling of radionuclide leakage from a point source at the NNPS footprint was included in **Section 5.11** (Geohydrology). Modelling results indicated that movement of contamination towards groundwater abstraction points in the surrounding areas is not possible.

7.4.2.2 Normal Operational Discharges to the Environment

Dose assessment for normal continuous discharges of the NNPS is done with the code *PC-CREAM 08* (UK HPA, 2009). There are various similar codes available internationally to perform a prospective dose assessment, such as RESRAD. *PC-CREAM 08* was chosen because of its extensive international user base. It was also used in the generic design assessments of NNPS in the United Kingdom, e.g. the UK EPR and AP1000 (UK EA, 2011).

PC-CREAM 08 is a complex model that has two main divisions called 'Models' and 'ASSESSOR'. The Models division includes a series of mathematical models that predict the transfer of radionuclides through the environment and provide estimates of activity concentrations in various environmental media following a continuous discharge. The output of these models is then used as input to the dose assessment part of the program ASSESSOR. A more detailed discussion of *PC-CREAM 08* is provided in **Appendix 7.1**.

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7.4.2.3 Minor Occurrences

Routine operational discharges are assessed by assuming that these discharges occur continuously and uniformly over a year. However, during normal operations, short-term discharges associated with minor occurrences¹ (also referred to as operational transients) are possible. Conditions during which there is a likelihood for these discharges are for example (IAEA, 2010):

- during maintenance operations;
- refuelling outages and reactor start-up;
- purging a reactor cooling system;
- nuclear fuel leaks requiring reactor shutdown accompanied by an operator error causing release to the atmosphere of the gaseous waste product system before adequate decay time has been allowed for short-lived radionuclides.

An analysis of the annual public dose should include short-term discharges following minor occurrences (DoE, 2011). Discharging radioactive material to the atmosphere over the short term may lead to doses that are higher than would be expected if it were assumed that the same discharge takes place uniformly over a year. This is mainly due to the fact that short-term discharges can lead to a peaking of activity concentrations in air and foodstuffs, which, combined with seasonal agricultural practices and variation in public habits, can lead to higher doses than normal.

The potential short-term doses are only assessed for gaseous discharges. In the case of liquid discharges to the marine environment, a much lower radiological impact is expected when compared to airborne discharges. Liquids are stored in holding tanks prior to being discharged at certain controlled times. Liquid discharges are regular short-term discharges which occur repeatedly through the year and are modelled as continuous releases. The discharge rate when pumping from a liquid waste storage tank is limited and it is unlikely, for example, that a month's liquid discharge volume can be released into the marine environment over a period of few hours. Also, for cooling water discharges via a pipeline into the sea and away from the near shore, the timescale of the release is less important than for atmospheric releases.

The code *ECOSYS* (Müller H., 2012) was used to calculate the doses resulting from minor occurrences and short-term discharges to the atmosphere. *ECOSYS* is a further developed program version of the model *ECOSYS-87*, which was used as the basis for the dose assessment in the German Integrated Measurement- and Information System (IMIS). Moreover, the *ECOSYS-87* model is one of two options that can be used in

¹ Minor occurrences are considered to be more frequent than anticipated operational occurrences (AOO) that are analysed as part of the design basis of an NNPS in the next licensing phase of construction.

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the *PC COSYMA* code. It is used in the European Realtime Decision Support System RODOS for dose assessment, as well as in radiological decision support systems of Austria, Switzerland and Hong Kong. *ECOSYS* has been adapted by the code developers for southern hemisphere seasonal conditions in South Africa.

The dose results are discussed in **Subsection 7.10.2** and **Appendix 7.6**.

7.4.2.4 Direct Radiation

Direct ionising radiation from the NNPS structures, such as the reactor and nuclear fuel buildings, is an additional but minor component of the total annual dose to a member of the public. The direct radiation dose is estimated based on the methodology described in **Subsection 7.10.3**.

7.4.2.5 The Radiological Impact on Non-Human Species

There are no regulatory radiation dose limits for non-human biota. However, the protection of non-human species against radiation damage requires that the exposure to non-human biota be determined (NNR, 2016). The *ERICA Tool* software system was used to perform a screening assessment of the dose rates to two generic sets of reference species consisting of terrestrial and marine biota. *ERICA* is defined as an “integrated approach to scientific, managerial and societal issues concerned with the environmental effects of contaminants emitting ionising radiation, with emphasis on biota and ecosystems” (Beresford, 2007). **Appendix 7.2** provides more detail on the software system.

7.5 Source Terms of Normal Operational Discharges to the Environment

The methodology used to derive the airborne and liquid source terms for the siting assessment is based on a bounding approach intended to conservatively represent the maximum envisaged full-site thermal capacity of 33 000 MW_{th}.

Four Generation III Pressurised Water Reactor (PWR) designs were selected as reference Nuclear New Power Station (NNPS) technologies. These designs represent credible procurement candidates for South Africa, have well-developed radiological effluent data available from vendors, and cover a range of reactor sizes and radioactive waste management technologies. The use of multiple reactor designs ensures that the source term development is not dependent on a single technology and provides a representative range of potential radionuclide releases.

The selected reference reactor designs are:

- (1) AP1000 – U.S.A. (Westinghouse, 2007)

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- (2) EPR – France (AREVA, 2007)
- (3) AP1400 – Korea (KEPCO, 2018)
- (4) HPR1000 - China (GNS, 2020)

For each reactor design, vendor-provided annual radionuclide-specific airborne and liquid effluent release data under normal operating conditions were compiled.

As the selected reactor technologies have different thermal outputs, the radionuclide-specific source terms were normalised to units of becquerels per megawatt thermal (Bq/MW_{th}) to establish a common basis for comparison. The normalised source terms were subsequently scaled to a total site thermal capacity of 33 000 MW_{th}, corresponding to the maximum envisaged site capacity.

The number of reactor units required to achieve a total thermal output of 33 000 MW_{th} was calculated for each reference design, as shown in the calculation below and also presented in **Table A7.3.1**.

$$\begin{aligned}
 \text{Reactor units per 33000 MWth} &= \frac{33000}{\text{MWth per reactor unit}} \\
 &= \frac{33000}{3415} \\
 &= 9.66
 \end{aligned}$$

For each radionuclide, the highest annual activity obtained from the scaled source terms of the four reference reactor designs was selected. Consequently, the maximum value for a given radionuclide may originate from a different reactor design than the maximum value for another radionuclide.

The resulting airborne and liquid source terms therefore constitute a composite enveloping (bounding) source term comprising the maximum radionuclide-specific values from the reference reactor designs. This approach is intentionally conservative and ensures that the source term used in the siting assessment bounds the releases associated with the range of credible Generation III reactor technologies considered.

Table A7.3.2 and **Table A7.3.3** present the annual radionuclide-specific liquid and airborne discharges, respectively, together with the corresponding source terms scaled to a total site thermal capacity of 33 000 MW_{th}. Blank entries indicate that no values were reported for the corresponding radionuclide in the vendor reference documentation.

Accordingly, the source terms presented in Appendix A-7.3 represent conservative bounding airborne and liquid source terms for a site operating at the maximum envisaged thermal capacity of 33 000 MW_{th} and are

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considered appropriate for use in the siting assessment.

The source term for a minor occurrence is based on a scenario during which it is assumed that the total annual airborne source term for normal continuous NNPS operation is discharged during a 24h period (refer **Subsection 7.10.2**).

7.6 Environmental Dispersion of Airborne Discharges

Long-term average values of atmospheric concentrations and ground deposition from continuous discharges are calculated using a sector-averaged version of the Gaussian plume model and included as *PLUME* in *PC-CREAM* 08 (UK HPA, 2009). It assumes a laterally uniform concentration in each of the sixteen wind direction sectors considered for the site. This is a reasonable assumption because wind meanders over prolonged periods. The weather data used in *PLUME* were collected by the onsite weather station. It also provides the data reported in **Section 5.8** (Meteorology).

An NNPS with 33 000 MW_{th} generating capacity will consist of numerous reactor units and multiple stacks for airborne discharges. Discharges were assumed to be from a single discharge point at a 10 m height. This provides a conservative estimate of the environmental impact and public dose. The differences in atmospheric concentrations calculated with *PLUME* for different release heights are illustrated in **Figure 7.4**. The actual discharges for the NNPS will be at an effective height significantly above 10 m, resulting in lower concentrations in the air and on the soil per unit area and therefore a lower dose. The AP1000, for example, discharges most of the airborne effluent from a main plant vent that has an effective stack height of approximately 60 m. About 12 per cent of the total release takes place from the turbine building vent which has an effective stack height of approximately 40 m (AREVA, 2007).

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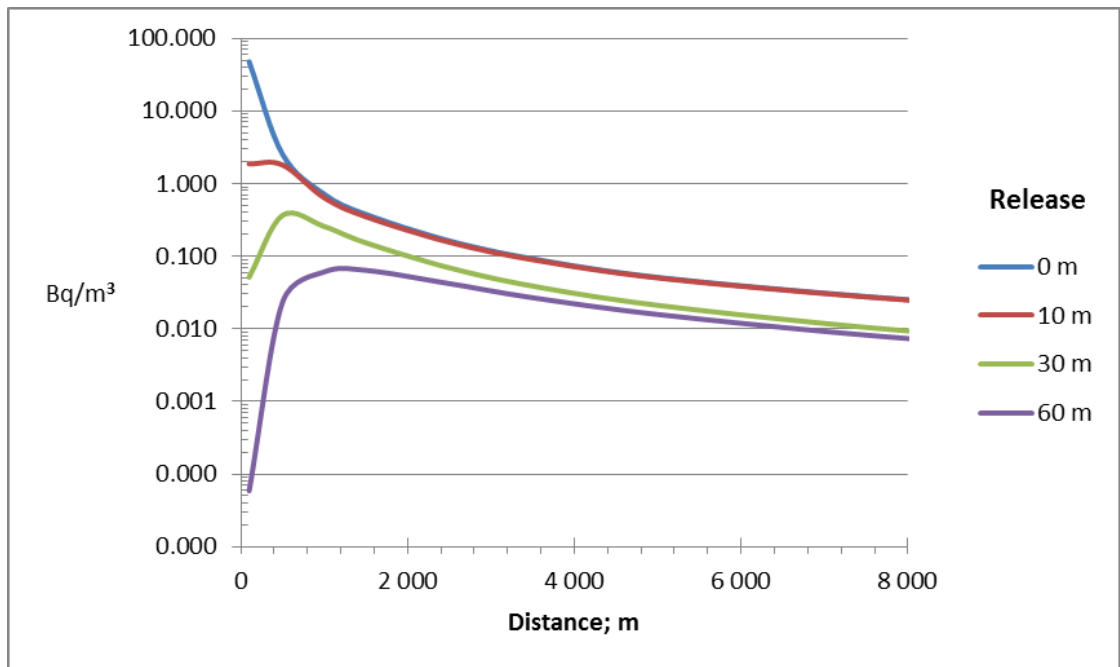


Figure 7.4: Atmospheric Concentrations as a Function of Discharge Height

The important parameters and their values used in the modelling of air and ground concentrations are listed in **Table 7.2**.

Table 7.2: Atmospheric Dispersion Parameters

Parameters	Values
Weather data	Site specific hourly weather data (TSSR Section 5.8)
Level of release	Release height - 10 m
Deposition velocity (ms^{-1})	Radionuclide particulates - 1×10^{-3} Iodine isotopes - 1×10^{-2} Noble gases – 0 H-3 and C-14 – dose calculated using the specific activity model
Rain washout coefficient (s^{-1})	1×10^{-4} , 0 (noble gases)
Surface roughness factor (m)	0.3 (typical of agricultural areas)

Figure 7.5 illustrates the relative importance of discharges to the atmosphere in each of the 16 wind sectors considered in the dose assessment. The graph represents annual meteorological data for the periods 2010 to 2012 (blue) and 2017 to 2019 (orange) and illustrates that

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routine airborne discharges will be mainly into the ENE to ESE sectors. The data were provided by AIRSHED who is responsible for **Section 5.8** (Meteorology) and these data are the only uninterrupted and continuous records available.

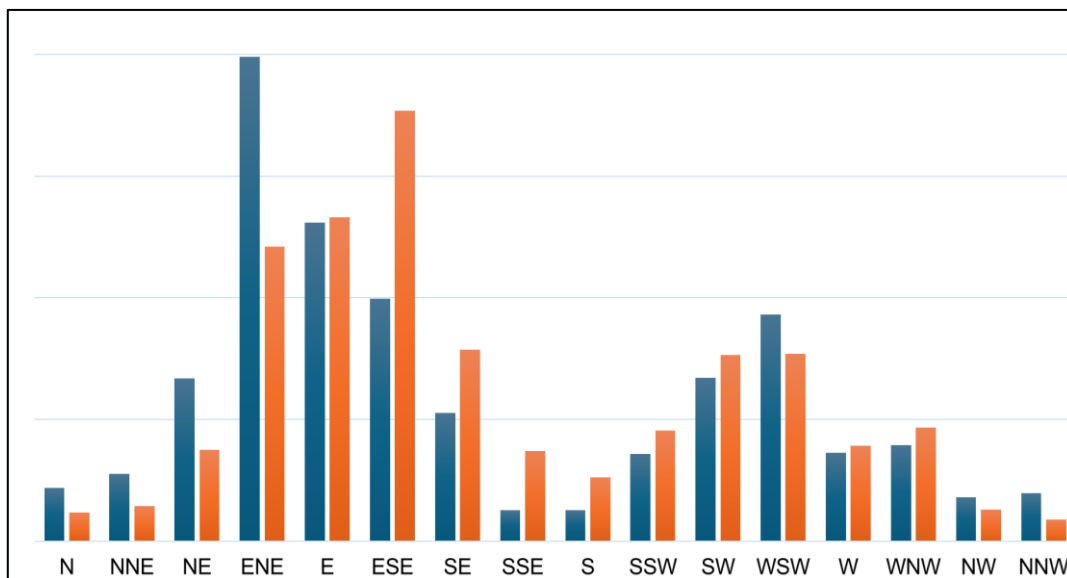


Figure 7.5: Relative Importance of the 16 Wind Sectors

7.7

Environmental Dispersion of Liquid Discharges

The proposed system for liquid discharges to the sea is illustrated in **Figure 7.6** (Eskom, 2024a). The design should result in improved dilution and a lower radiological impact from liquid discharges when e.g. compared to a surf-zone discharge which is the case at the Koeberg Nuclear Power Station (KNPS).

Dispersion modelling in terms of the cooling water thermal plume is discussed in **Section 5.9** (Oceanography and Coastal Engineering). It provides an indication of the expected dispersion of radioactive liquid discharges. It shows good dispersion characteristics in the local marine environment considered in the dose assessment.

The liquid radioactivity concentrations were calculated for a local marine compartment linked to a regional oceanic compartment using the *DORIS* marine model in *PC-CREAM 08* (UK HPA, 2009). The controlling parameters and their values used in *DORIS* are described in **Table 7.3**.

The annual average radioactivity concentrations calculated for the local marine compartment were used to estimate the dose for the site representative person based on the habits data included in **Subsection 7.9**. The dimensions of the local marine compartment were based on a conservative selection from typical dimensions of a large set of marine compartments described in *PC-CREAM 08*, and considered data used in the

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Duynefontyn Site Safety Report (Eskom, 2024b).

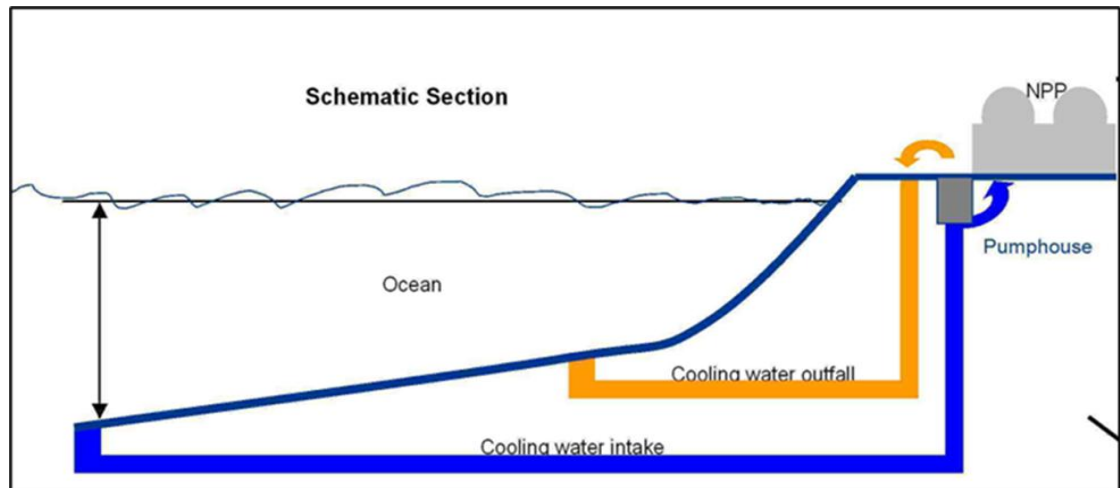


Figure 7.6: Cooling Water Intake and Outfall

Table 7.3: Marine Compartment Dispersion and Bioaccumulation Parameters

Marine Component	Volume (m ³)	Depth (m)	Coastline Length (m)	Volumetric Exchange Rate (m ³ /y)	Suspended Sediment Load (t/m ³)	Sedimentation Rate (t/m ² /y)	Sediment Density (t/m ³)	Diffusion Rate (m ² /y)
Local marine compartment	2.00E+08	1.00E+01	1.00E+04	4.00E+09	2.00E-04	1.00E-04	2.60E+00	3.15E-02
Regional ocean	8.98E+17	3.80E+03	--	--	1.00E-08	3.00E-06	2.60E+00	3.15E-03

7.8 Environmental Build-up of Radioactivity

An important aspect of the NNPS radioactive discharges is the potential build-up of radionuclides with a long decay half-life in the environment during 60 years of operation. Build-up results in an increasing annual dose over the lifetime of the NNPS (assuming that all other environmental factors remain constant). The radionuclide build-up in terrestrial soil and marine sediment is taken into account in the dose assessment using *PC-CREAM 08*. The annual public dose that is reported is the dose after 60 years of NNPS operation.

Table 7.4 shows two radionuclides to illustrate the build-up behaviour of different radionuclides. I-131 has a short half-life (8.04 days) reaching an equilibrium concentration in a short period when compared to, e.g. Cs-137. Cs-137 has a relatively long half-life (30.1 years), and its concentration will gradually increase during the operating life of the NNPS.

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Table 7.4 Radionuclide Build-Up in Marine Sediments

Years of Nuclear Installation Operation and Liquid Effluent Discharge	Marine Sediment Concentration (Bq/kg)		
	1 y	5 y	60 y
Cs-137: 6.93E+9 Bq/y T1/2 = 30 y	1.66E-01	7.21E-01	2.21E+00
I-131: 3.67E+8 Bq/y T1/2 = 8.04 d	1.74E-05	1.74E-05	1.74E-05

Figure 7.7 is a further illustration of radionuclides that are important for public dose assessment.

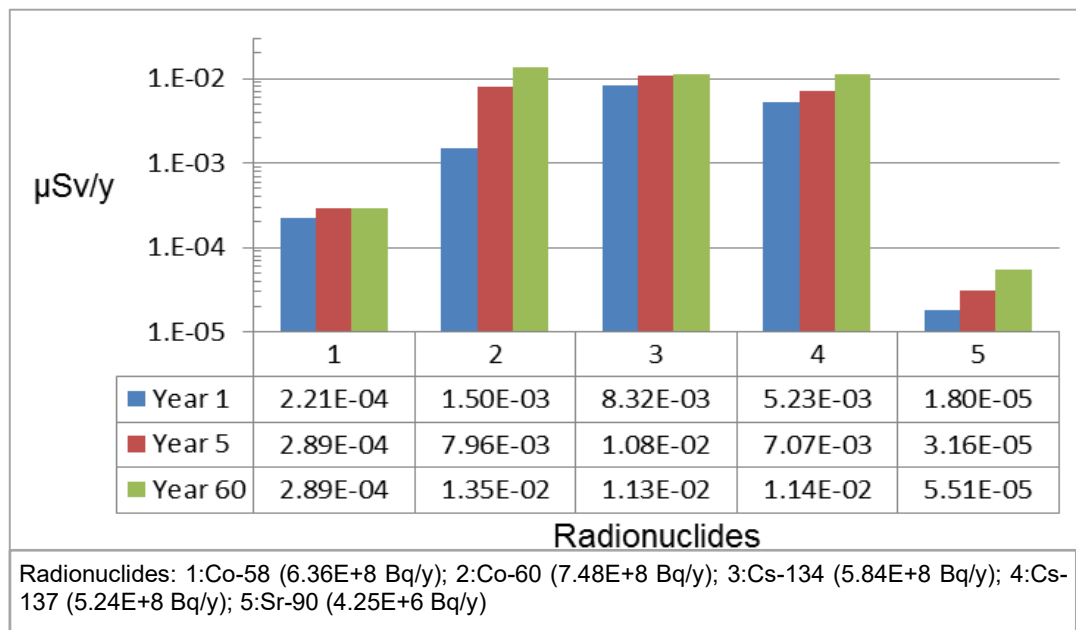


Figure 7.7: Environmental Build-Up of Radionuclides

7.9 Habits Data and the Site Representative Person

The first habits survey at the site was carried out in 2011 by the University of Western Cape (Linsay, 2011). A follow-up habits survey was carried out during the first quarter of 2024 and reported in (PSI, 2024). The main difference between the two surveys is the introduction of the concept of a PIA. The earlier survey did not include a distinction in respect of exposure pathways and associated habits inside and outside the PIA.

Habits of members of the public on farms and towns inside the PIA could result in non-trivial annual doses, i.e. a dose greater than 1 µSv/y and

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attributable to NNPS discharges. The exposure pathways and habits data for consumption of food, for example, are for food produced inside the PIA. A member of the public living inside the PIA but consuming all his/her food produced well beyond 10 km, may only experience exposure from inhalation and external radiation from airborne discharges and inter-tidal marine deposited radioactivity.

A representative person is defined for the site based on the high-rate values calculated for the habits data of the various exposure pathways and is described in (PSI, 2024). A high-rate value is determined by applying the 'cut-off method'. It is the arithmetic mean of an exposure pathway and its associated habits data that are between the maximum observed habit rate and one third of the maximum observed habit rate (the latter also referred to as the threshold value).

The habit rate values that were calculated and defined as exposure pathway 'critical' values in the previous UWC habits survey (UWC, 2011) are equivalent in definition to the high-rate values calculated for each of the different exposure pathway profiles defined in (PSI, 2024). These values are indicated as '*shaded*' values in the diagonals of **Table 7.5**, **Table 7.6** and **Table 7.7**. Each pathway profile is listed in the first column and its profile values contributed by the other exposure pathways are included in the corresponding table row. Refer also to the habits survey methodology document (PSI, 2023).

The representative person dose in respect of airborne discharges was assessed at different locations in the PIA. These locations and their distance and direction in respect of the NNPS weather station location which determined the meteorological data reference location used for the dose assessment, are as follows (PSI, 2024):

1. St. Francis Bay 7.5 km; 82 degrees;
2. Cape St. Francis – 9.0 km; 95.0 degrees;
3. Sea Vista – 9.0 km; 85 degrees;
4. Oyster Bay - 5.0 km; 284 degrees;
5. Umzamowethu – 4.0 km; 294 degrees;
6. Farm no.1 – 3.5 km; 321 degrees;
7. Farm no.2 – 3.0 km; 0 deg.

These locations represent human settlements nearest to the Eskom owner-controlled boundary (OCB) of the site and are illustrated in **Figure 7.8**.

Note that when no value is indicated for an exposure pathway, this means no habits data were recorded (in any of the specific age group observation records). It does not mean that no exposure occurs but that for the random selection of members of the public interviewed, no person reported a habit for the specific pathway.

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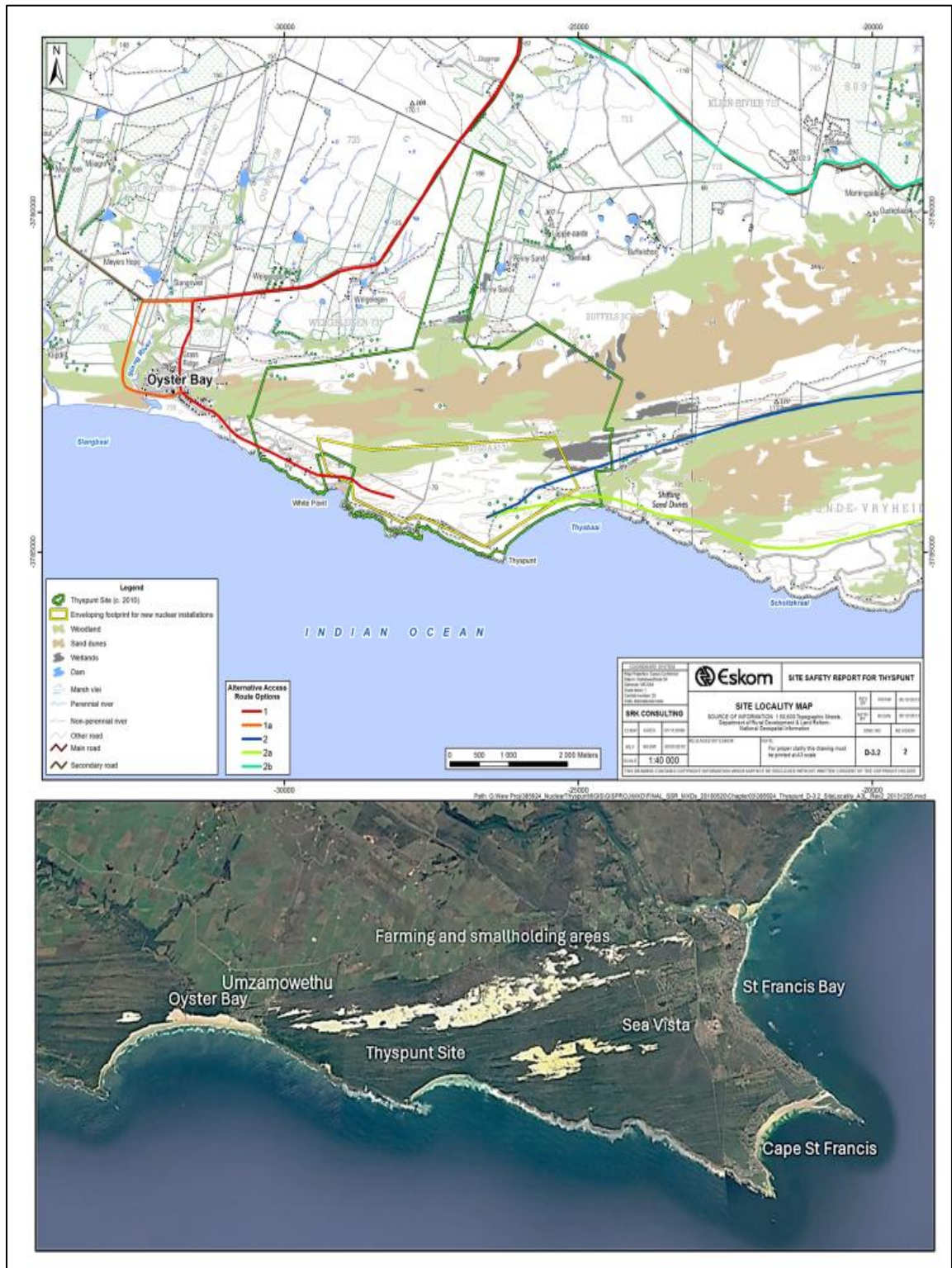


Figure 7.8: The Thyspunt site and human settlements in the PIA

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Table 7.5: High-rate values - Adult Exposure Pathway Profiles

Exposure Pathway Profile	Time Spent on the Beach (converted to digital value); h/y	Root vegetables; kg/y	Broad leaf (green) vegetables; kg/y	Fruits; kg/y	Grain/cereals; kg/y (mainly in Area 6 - farms, smallholdings	Beef; kg/y	Cattle liver; kg	Mutton consolidated	Milk; ℓ /y	Dairy products; kg/y or ℓ /y	Eggs; kg/y (0.035 kg/egg)	Fish; kg/y	Crustaceans (crayfish, prawn); kg/y	Molluscs; kg/y
Beach	1091	45.1	30.6	15.5	19.5	24.0		8.6			15.5	19.6	19.2	5.5
Root vegetables	361	114.0	34.1	15.1	22.0	24.0	0.5	20.6	81.0	63.4	15.6	8.2	24.0	2.3
Broad leaf vegetables	494	73.2	46.4	8.9	20.4	22.2	0.8	54.1	40.0	90.8	19.6	11.8	24.0	4.0
Fruit	269	71.5	6.9	36.7	32.0			10.0	144.0	36.0	2.5			
Grain	261	26.8	7.2	10.4	45.0	60.5		29.5	48.0		4.8	20.8		4.8
Cattle meat (beef)	223	54.3	22.7		19.8	36.1		40.7	48.7	90.8	10.1	19.1		1.2
Cattle liver	130	129.0	41.3	5.3	14.0		0.7	9.4			21.0	14.7		4.0
Sheep meat (mutton)	72	51.6	18.0	10.0	17.8	31.8		64.9	55.1	90.8	15.1	24.1	24.0	

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Exposure Pathway Profile	Time Spent on the Beach (converted to digital value); h/y	Root vegetables; kg/y	Broad leaf (green) vegetables; kg/y	Fruits; kg/y	Grain/cereals; kg/y (mainly in Area 6 - farms, smallholdings	Beef; kg/y	Cattle liver; kg	Mutton consolidated	Milk; ℓ /y	Dairy products; kg/y or ℓ /y	Eggs; kg/y (0.035 kg/egg)	Fish; kg/y	Crustaceans (crayfish, prawn); kg/y	Molluscs; kg/y
Milk	120	40.7	6.6	59.2	17.8	19.3		37.0	136.9	64.9		26.3		1.2
Dairy product	115	56.3	25.2	59.2	29.2	26.3		40.0	75.4	67.1	11.8	19.6	24.0	
Eggs	456	58.2	34.0	6.0	22.2	37.7	1.0	16.4	18.0	90.8	17.3	12.0	24.0	2.6
Fish	461	32.4	15.8	4.6	19.3	31.7	1.0	24.0	55.7	90.8	21.0	43.7	19.2	8.5
Crustaceans	494	91.3	30.5		29.2			49.8	18.0	90.8	25.2	17.8	21.3	19.2
Molluscs	667	12.0	6.0									29.4	19.2	11.6

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Table 7.6: High-rate values - Child exposure pathway profiles

Exposure Pathway Profile	Time Spent on the Beach (converted to digital value); h/y	Root vegetables; kg/y	Broad leaf (green) vegetables; kg/y	Fruits; kg/y	Grain/cereals; kg/y (mainly in Area 6 - farms, smallholdings	Beef; kg/y	Cattle liver; kg/y	Mutton consolidated	Milk; ℓ /y	Dairy products; kg/y or ℓ y	Eggs; kg/y (0.035 kg/egg)	Fish; kg/y	Crustaceans (crayfish, prawn); kg/y	Molluscs; kg/y
Beach	1190	22.4	7.2		15.1			13.4			10.1	18.5		
Root vegetables	659	37.7	17.7	3.0	8.2		0.1	5.0				12.7		
Broad leaf vegetables	358	48.5	19.4	3.0	12.5		0.1	6.7				8.0		
Fruit	338	32.0	14.1	11.0	8.2		0.1	5.0			2.5	4.0		
Grain	784	16.8	11.3	6.5	13.0		0.1	5.0			10.1	19.0		
Cattle meat (beef)	26					10.1			50.7			1.6		
Cattle liver	234	32.0	24.2	3.0	8.3		0.1	5.0				4.0		
Sheep meat (mutton)	598	32.0	17.4	3.0	8.3		0.1	8.4				4.0		

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Exposure Pathway Profile	Time Spent on the Beach (converted to digital value); h/y	Root vegetables; kg/y	Broad leaf (green) vegetables; kg/y	Fruits; kg/y	Grain/cereals; kg/y (mainly in Area 6 - farms, smallholdings	Beef; kg/y	Cattle liver; kg/y	Mutton consolidated	Milk; ℓ /y	Dairy products; kg/y or ℓ y	Eggs; kg/y (0.035 kg/egg)	Fish; kg/y	Crustaceans (crayfish, prawn); kg/y	Molluscs; kg/y
Milk	124					13.0			134.0			2.3		
Dairy product														
Eggs	573	3.0	1.0		9.6			0.7	12.0		5.0	7.0		
Fish	1040	11.7	5.6		15.1						10.1	24.6		
Crustaceans														
Molluscs														

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Table 7.7: High-rate values - Infant exposure pathway profiles

Exposure Pathway Profile	Time Spent on the Beach (converted to digital value); h/y	Root vegetables; kg/y	Broad leaf (green) vegetables; kg/y	Fruits; kg/y	Grain/cereals; kg/y (mainly in Area 6 - farms, smallholdings	Beef; kg/y	Cattle liver; kg/y	Mutton consolidated	Milk; ℓ /y	Dairy products; kg/y or ℓ /y	Eggs; kg/y (0.035 kg/egg)	Fish; kg/y	Crustaceans (crayfish, prawn); kg/y	Molluscs; kg/y
Beach	436		1.5	5.0							6.3	5.4		
Root vegetables		0.5		0.7	2.0				24.0		0.7			
Broad leaf vegetables	78		5.9		3.0	14.0		31.5	24.0			3.0		
Fruit	104	0.5		2.9	2.0				24.0		3.5			
Grain	78	0.5	3.0	0.7	2.7	14.0		31.5	24.0		0.7	3.0		
Cattle meat (beef)														
Cattle liver														
Sheep meat (mutton)	78		3.0		3.0	14.0		31.5	24.0			3.0		

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Exposure Pathway Profile	Time Spent on the Beach (converted to digital value); h/y	Root vegetables; kg/y	Broad leaf (green) vegetables; kg/y	Fruits; kg/y	Grain/cereals; kg/y (mainly in Area 6 - farms, smallholdings	Beef; kg/y	Cattle liver; kg/y	Mutton consolidated	Milk; ℓ /y	Dairy products; kg/y or ℓ /y	Eggs; kg/y (0.035 kg/egg)	Fish; kg/y	Crustaceans (crayfish, prawn); kg/y	Molluscs; kg/y
Milk	78	0.5	3.0	0.7	2.7	10.5		31.5	18.9		0.7	2.2		
Dairy product														
Eggs	104	0.5		2.9	2.0				24.0		3.5			
Fish	225		3.0		3.0	14.0		31.5	24.0			5.5		
Crustaceans														
Molluscs														

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7.10 Annual Dose to the Public

7.10.1 Normal Continuous Discharge Dose

Site dose coefficient factors (DCFs) are defined as annual dose per unit radioactivity discharged to the air and sea as a function of the site-specific environmental dispersion conditions and habits data selected for the representative person². The annual dose is calculated by adding the product of each nuclide in the airborne and liquid discharge source term for all nuclides for normal operation and its DCFs.

The DCFs for the different human settlements are compared in **Table 7.8** (refer to **Appendix 7.4**). It was determined that a representative person in the 'Adult' age group and located in the ENE sector at St. Francis Bay receives the highest annual dose. The dose calculations included the following conservatism. No credit was taken for time spent indoors and shielding from gamma and beta radiation from the plume as well as from deposited radioactivity on the ground.

Table 7.8: Total DCF for Different locations and Age Groups for Airborne Discharge (µSv per Bq/y)

PIA Area	Adult	Child	Infant
Oyster Bay	6.68E-10	2.26E-10	1.16E-10
Umzamowethu	9.95E-10	3.28E-10	1.62E-10
Farm No.1	1.35E-09	4.55E-10	2.29E-10
Farm No.2	9.23E-10	2.76E-10	1.41E-10
St. Francis Bay	1.82E-09	5.79E-10	2.79E-10
Sea Vista	1.30E-09	4.14E-10	2.01E-10
Cape St. Francis	1.30E-09	4.14E-10	2.10E-10

The liquid DCFs are derived for the local marine compartment and it is conservatively assumed that all members of the public at the townships and farms experience exposure from the exposure pathways from the same localised marine compartment at the site as described in **Subsection 7.7**. The habits data associated with liquid discharges, however, were collected in a much larger marine area that includes the marine and coastal areas of St. Francis Bay, Cape St. Francis and Oyster Bay.

² The term dose per unit release at the site (DPUR) is sometime used for site DCF.

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Table 7.9: Cumulative Site DCFs for Age Groups at the end of 60 y for Liquid Discharges (μSv per Bq/y)

Adult μSv per Bq/y	Child μSv per Bq/y	Infant μSv per Bq/y
3.34E-09	1.02E-09	6.70E-10

The annual dose to the representative person from each of the radionuclides in the enveloping airborne and liquid source terms are included in **Appendix 7.5**. The total dose is summarised in **Table 7.10**.

Table 7.10: Annual Dose to the Representative Person from Normal Operational Discharges to the Environment

Total Liquid Dose ($\mu\text{Sv/y}$)	Total Airborne Dose ($\mu\text{Sv/y}$)	Total Annual Dose ($\mu\text{Sv/y}$)
137.53	27.23	164.76

7.10.2 Public Dose from Minor Occurrences during Normal Operation

NNPS annual operation may involve minor occurrences or ‘upset conditions’ that result in discharges not included in the normal operation source terms (refer to **Subsection 7.4.2.3**). The regulations on licensing of sites for new nuclear installations require an analysis of the impact on the public annual dose of minor occurrences that can be kept under control (DoE, 2011).

The method for assessing the dose contribution from minor occurrences is different to the method used for normal continuous discharges. The transient nature of the radioactive contamination in the environment is estimated by considering the short duration of a postulated airborne discharge (typically hours/days) and using dynamic food chain models. The approach followed in this report is based on the assessment framework for short-term discharges used in the pre-construction environmental report (PCER) of the UK EPR (EDF, 2010). The results by Electricité de France (EDF) were validated by the UK Environmental agency (UK EA, 2010). The dose assessment results for Thyspunt were compared to the UK EPR results.

The main input data required to calculate the dose with ECOSYS are:

- the atmospheric dispersion factor (X/Q s/m³) at the representative person location;
- the integrated airborne radioactivity;
- the representative person habits data.

The integrated airborne radioactivity is estimated assuming a dispersion

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factor equal to $5\text{E-}06 \text{ s/m}^3$ at the location of the representative person and discussed in **Appendix 7.6**.

The source term for the site is defined in **Table 7.11**. It is based on the radionuclides selected for the UK EPR assessment and considered most important in terms of dose. It is assumed that there is at least one minor occurrence per reactor unit during a year. It is further assumed that the equivalent of the total annual continuous airborne source term is discharged during a 24h period, the same period assumed for the UK EPR. In the case of the UK EPR, the dose is calculated at 800 m whereas the nearest human settlement at Thyspunt is approximately 3.5 km away from the NNPS. Note that for normal continuous discharges discussed in **Subsection 7.10.1**, the representative person is located 9 km in an ENE direction where the highest dose was assessed for all the human settlements considered in the PIA.

Table 7.11: Source Terms and Atmospheric Concentrations

Radionuclide	TSSR at 3 km ENE; X/Q = $5\text{E-}06$			Single UK EPR at 800 m; X/Q = $1\text{E-}04$		
	Bq released in 24 h	Bq/s	Bq/m ³	Bq released in 24 h	Bq/s	Bq/m ³
I-131	1.84E+09	5.83E+01	2.92E-04	1.82E+08	2.11E+03	1.05E-02
Kr-85	1.50E+15	4.75E+07	2.38E+02	6.95E+11	8.04E+06	4.02E+01
Xe-133	1.09E+14	3.45E+06	1.73E+01	3.16E+12	3.66E+07	1.83E+02
Xe-135	3.27E+13	1.04E+06	5.18E+00	9.90E+11	1.15E+07	5.73E+01
Ar-41	1.26E+13	3.99E+05	2.00E+00	1.45E+11	1.68E+06	8.39E+00
Xe-131m	6.75E+14	2.14E+07	1.07E+02	1.50E+10	1.74E+05	8.68E-01
I-133	7.05E+09	2.23E+02	1.12E-03	2.18E+08	2.52E+03	1.26E-02
Co-58	6.36E+08	2.02E+01	1.01E-04	4.34E+07	5.02E+02	2.51E-03
Co-60	7.48E+08	2.37E+01	1.19E-04	5.12E+07	5.93E+02	2.96E-03
Cs-134	2.42E+10	7.67E+02	3.83E-03	3.98E+07	4.61E+02	2.30E-03
Cs-137	5.23E+08	1.66E+01	8.29E-05	3.57E+07	4.13E+02	2.07E-03

The representative person habits data used in the short-term dose assessment are summarised in **Table 7.12**.

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Table 7.12: Representative Person Habits Data

Inhalation and external radiation; no shielding and credited	Root vegetables; kg/y	Broad leaf (green) vegetables; kg/y	Fruits; kg/y	Grain/cereals; kg/y (mainly in Area 6 - farms, smallholdings	Beef; kg/y	Cattle liver; kg/y	Mutton consolidated	Milk; L/y	Dairy products; kg/y or L/y	Eggs; kg/y (0.035 kg/egg)
8766 h	114.0	46.4	36.7	45.0	36.1	0.7	64.9	136.9	67.1	17.3

The source term used in ECOSYS excludes two important radionuclides, C-14 and H-3, which cannot be modelled with *ECOSYS*. A specific activity approach is adopted for these nuclides. It is the same *PC-CREAM 08* methodology used for normal continuous operational releases. It is assumed that all foodstuffs come into rapid equilibrium with the radioactivity in air following a 24h discharge. The specific activity of each radionuclide in the food consumed by the representative person is equal to the atmospheric concentration at the location of the representative person. It is expressed as follows for C-14 and H-3:

$$C_{\text{food}} = C_{\text{Air}} \times F;$$

where F is a conversion factor relating the airborne concentration to the concentration in foodstuffs for a continuous release included in **Table 7.13** (UK HPA, 2009).

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Table 7.13: C-14 and H-3 Conversion Factors

Foodstuff	Conversion factor F (Bq/kg per Bq/m ³)	
	H-3	C-14
Green (broadleaf) vegetables	112.5	267
Root vegetables	100	533
Fruit	100	533
Cow Milk	112.5	267

The short discharge duration of 24 h is accounted for by dividing the 24 h discharge period by the number of hours per year, i.e. $24/8766 = 2.74\text{E-}03$. **Appendix 7.6** provides more detail on the assumptions and parameter values used in the dose assessment.

The representative person annual dose attributable to minor occurrences is summarised in **Table 7.14**.

Table 7.14: Annual Dose from Minor Occurrences

Radionuclide category	Annual dose attributed to minor occurrences (μSv/y)
Fission and activation products	0.026
Iodine isotopes	0.006
Noble gases	0.195
H-3	0.080
C-14	5.860
Total Short-term dose	6.167

The site dose results can be compared to dose calculated for the UK EPR in **Table 7.15**. The age group of the UK EPR representative person was determined to be 'infant' whereas for the Thyspunt site is 'adult'. The comparison should take into account that the dose for the UK EPR is

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reported for a single EPR. It can be concluded that the UK EPR dose result is the same order of magnitude even when it is scaled to 7 EPR units when considering the site 33 000 MW_{th}³.

Table 7.15: UK EPR Dose from Minor Occurrences

UK-EPR	Adult (μSv/y)	Child (μSv/y)	Infant (μSv/y)
Fission and activation products	0.144	0.079	0.059
Iodine isotopes	0.009	0.110	0.023
Noble gases	0.033	0.020	0.015
H-3	0.020	0.022	0.044
C-14	0.659	0.758	1.320
Total Short-term dose	0.865	0.989	1.461

7.10.3 Direct radiation from NNPS Reactor and Fuel Buildings

Design specifications and radiation protection programmes at NNPS require that areas are designated as controlled, supervised and non-controlled areas (ICRP, 2006). The outside of the reactor, nuclear fuel and waste storage buildings are classified non-controlled areas. Ambient dose levels must be less than 1 mSv/y. The dose at the boundary of the site and where the nearest members of the public could reside can be estimated using 1 mSv/y at 1 m from an NNPS building surface, as a radiation source. The OCB is at an approximate distance of 2 km from the NNPS and the dose rate at the OCB can be estimated using the following ratio:

Direct radiation dose rate = Dose rate at the NNPS × 1/R;

where R is the distance away from an NNPS building measured in meters.

This relationship between source and distance is more restrictive than what typically applies to a point source which the NNPS approaches at large distances, i.e. 1/R². The dose to a member of the public, assuming an unlikely scenario of permanently located at the OCB, is:

$$\text{OCB} \leq 0.5 \mu\text{Sv/y};$$

The decrease in dose with distance is illustrated in **Figure 7.9**.

³ Note that the UK EPR dose was assessed at a distance of 800 m and the site NNPS at 3 km.

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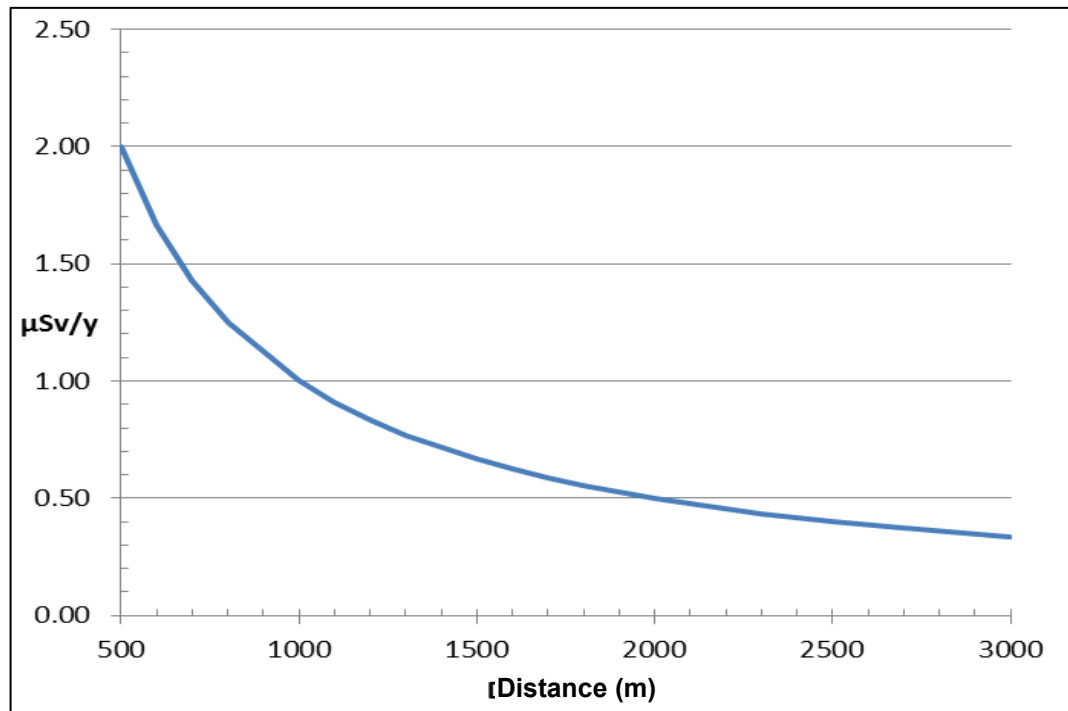


Figure 7.9: Direct Radiation as a Function of Distance from NNPS

7.10.4 Representative Person Total Annual Dose

The total annual dose to a member of the public, estimated in terms of a representative person for the site, is presented in **Table 7.16**.

Table 7.16: Annual Dose to the Thyspunt Site Representative Person

Source	Dose
Normal operation and continuous discharges (μSv/y)	164.85
Contingency discharges during minor occurrences (μSv/y)	6.17
Direct radiation from NNPS buildings (μSv/y)	0.50
<i>Total representative person dose (μSv/y)</i>	<i>171.52</i>

7.11 Radiological Impact on Non-Human Species

The latest version of the ERICA Assessment Tool (version 2.0.230) was used to estimate the ionising radiation dose to non-human biota at the site. The dose rates were estimated for two sets of generic species included in ERICA and representing the terrestrial and marine environments (Beresford, 2007). The dose rate screening values can be selected as follows:

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- ERICA's default incremental screening dose rate value of 10 $\mu\text{Gy/h}$ for all ecosystems, or
- 40 $\mu\text{Gy/h}$ for terrestrial animals or 400 $\mu\text{Gy/h}$ for terrestrial plants. For aquatic species a value of 40 $\mu\text{Gy/h}$ is applied to mammals, reptiles, amphibians and birds or 400 $\mu\text{Gy/h}$ for all other species. These numbers are derived from the IAEA and UNSCEAR (United Nations Special Committee on the Effects of Atomic Radiation) reports and are really benchmarks below which populations are unlikely to be significantly harmed based on reviews of the scientific literature. These also correspond to the United States Department of Energy (US DoE) dose limit of 10 mGy/d (approximately 400 $\mu\text{Gy/h}$) for native aquatic animals and benchmarks of 400 and 40 $\mu\text{Gy/h}$ for terrestrial plants and terrestrial animals, respectively used in the US DoE's graded approach.

The default screening value of 10 $\mu\text{Gy/h}$ used for all ecosystems and organisms is a proposed generic screening value below which 95 per cent of all species should be protected from ionising radiation. The 10 $\mu\text{Gy/h}$ criterion is a screening value which should be used to screen out sites of low concern. It is not intended that this screening value be used as a dose rate limit. There is consensus that dose rates below 40 $\mu\text{Gy/h}$, indicate that there will be no adverse effects.

ERICA assessments can be carried out at three levels:

- Tier 1 is simple and conservative; it requires a minimal amount of input data, the user can select radionuclides from a default list, and the results are for the most sensitive combination of reference organisms.
- Tier 2 is more specific and less conservative; the user can enter input data such as radionuclides that are not on the default list and edit transfer parameters. The results are calculated for each reference organism individually.
- The situations requiring a Tier 3 assessment are likely to be complex and unique. Tier 3 is a probabilistic risk assessment in which uncertainties within the results may be determined using sensitivity analysis. A Tier 3 assessment requires consideration of biological effects data.

ERICA Tier 2 risk assessments were carried out for marine and terrestrial reference organisms using site specific data and listed in **Appendix 7.2**.

The estimated total (internal and external summed) dose rates for each reference organism included in the assessment are compared with the dose rate screening values. A risk quotient, RQ, for each specific radionuclide selected for inclusion in the assessment is calculated as follows:

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- $RQ_{ro} = (DR^{ro}_{Tot}) \div (SDR)$
- RQ_{ro} = Risk quotient for reference organism 'ro';
- DR^{ro}_{Tot} = total (weighted or unweighted) absorbed dose-rate ($\mu\text{Gy/h}$) for each reference organism 'ro', and
- SDR = the screening dose rate ($\mu\text{Gy/h}$) selected.

If the RQs are below 1 for all organisms, then the assessment has not exceeded the screening level. An uncertainty factor of 3 or 5 (or higher) was used and therefore there is a low probability that the estimated dose rate to any organism exceeds the incremental screening dose rate if RQs are below 1. The resulting risk to non-human biota can then be considered trivial.

If the expected value RQ (and by implication the conservative RQ) is above 1 for any organism, then the assessment has exceeded the screening value at Tier 2 and the ERICA Tool will recommend that further assessment be conducted.

7.11.1 Marine organisms

Two important element specific input parameters that are required are:

- KD distribution coefficients that define the partitioning of the nuclides between the dissolved and solid phases, and
- CR values of nuclide concentrations in organisms relative to the environmental media.

Default values are available in ERICA for the nuclides included in the site assessment. The selections were done following the recommendations in ERICA in the absence of empirical data:

- Use an available CR value for an organism of similar taxonomy within that ecosystem for the radionuclide under assessment (a preferred option) – for example, a value for marine pelagic fish was assumed to be applicable to marine benthic fish.
- Use an available CR value for a similar reference organism (a preferred approach) – for example, available CR values for one vertebrate reference organism were applied to other vertebrate reference organisms.
- Use CR values recommended in previous reviews or derive them from previously published reviews (a preferred approach) - in some instances, it was necessary to use broad reviews of stable element concentrations in media and biota to derive CR values or adopt previously recommended values without being able to go back to the source reference to confirm these.
- Use specific activity models for H-3 and C-14 (a preferred approach) - specific activity models were used to derive H-3 and C-14 CR values for

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all reference organisms in terrestrial ecosystems (no values were based on observed data).

- Use an available CR value for the given reference organism for an element of similar biogeochemistry; for instance, available CR values for transuranic and lanthanide elements were used if CRs were not available for another member of these series.
- Use an available CR value for biogeochemically similar elements for organisms of similar taxonomy; for instance, actinide element CRs for marine reptiles were assumed to be the same value as for marine birds.
- Use an available CR value for biogeochemically similar elements available for a similar reference organism - for instance, Nb CRs for marine vertebrates were derived from available Zr values.
- Use allometric relationships, or other modelling approaches, to derive appropriate CRs - for instance, CRs for wild bird eggs were derived from available CRs for wild birds and published relationships between radionuclide concentrations in eggs and meat of domestic poultry. Assume the highest available CR (a least preferred option) - this option was used on a few occasions only to provide Po and Tc CR values for terrestrial invertebrate reference organisms and a small number of Ru and C CRs for freshwater reference organisms.
- For aquatic ecosystems use (if justified) an appropriate CR value for the reference organism in a different ecosystem (a least preferred option); in the ERICA Tool freshwater database, CR values for the same reference organism in the marine ecosystem (from the ERICA marine database) were assumed for a limited number of freshwater CR values.

The procedure that was followed to prepare site specific input data for ERICA Tool (marine biota) is as follows:

- Select unfiltered seawater and sediment concentrations per unit nuclide activity from DORIS marine dispersion results used in the PRIPE Method Document (Eskom, 2021). The 60-year integrated values are used.
- Select the maximum Gen III NNPS¹ liquid source terms and the total nuclide specific unfiltered seawater and sediment concentrations are calculated.
- Select the principal nuclides from the site liquid source term and use their unfiltered seawater and sediment concentrations as input data to ERICA Tier 2. The principal nuclides are selected by assessing the nuclide importance in respect of its Environmental Media Concentration Limits (EMCL Bq/l) provided in ERICA Tier 1 and the total liquid source term per nuclide.

The data used in the procedure are included in **Appendix 7.2, Table A-7.2.7.1** to **Table A-7.2.7.4**. The results of the risk assessment for

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marine reference organisms are shown in **Table 7.17**. It is concluded that the liquid discharges from the NNPS¹ are unlikely to pose a risk.

Table 7.17: ERICA Marine organisms – Screening value equal to 10 µGy/h

Organism	Total Dose Rate per organism (µGy/h)	Screening Value (µGy/h)	Risk Quotient (expected value) (unitless)	Risk Quotient (conservative value) (unitless)
Benthic fish	6.92E-02	1.00E+01	6.92E-03	2.08E-02
Bird	6.87E-02	1.00E+01	6.87E-03	2.06E-02
Crustacean	6.80E-02	1.00E+01	6.80E-03	2.04E-02
Macroalgae	4.70E-02	1.00E+01	4.70E-03	1.41E-02
Mammal	8.21E-02	1.00E+01	8.21E-03	2.46E-02
Mollusc - bivalve	7.31E-02	1.00E+01	7.31E-03	2.19E-02
Pelagic fish	7.01E-02	1.00E+01	7.01E-03	2.10E-02
Phytoplankton	3.32E-02	1.00E+01	3.32E-03	9.97E-03
Polychaete worm	6.35E-02	1.00E+01	6.35E-03	1.91E-02
Reptile	8.20E-02	1.00E+01	8.20E-03	2.46E-02
Sea anemones & True coral	6.28E-02	1.00E+01	6.28E-03	1.89E-02
Vascular plant	4.72E-02	1.00E+01	4.72E-03	1.42E-02
Zooplankton	8.20E-02	1.00E+01	8.20E-03	2.46E-02

¹ The source term is calculated for the sites that represents 33 000 MWth generated by four reference Gen III NNPS (AP 1000, EPR, AP 1400 and HPR 1000).

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7.11.2 Terrestrial organisms

The procedure that was followed to prepare site specific input data for ERICA (terrestrial biota) is as follows:

- The relative importance of the nuclides in the airborne source term was determined by calculating the ratio of the product of the nuclide's source term and its EMCL value to the product of the C-14 source term and EMCL value. C-14 has the lowest EMCL value, i.e. the highest dose per unit activity. Nuclides that have a value less than 1E-06 were screened out because of its negligible dose contribution.
- The soil activity of each nuclide following build-up over 60 years continuous discharge, is calculated using the results of PLUME and GRANIS in the PC-CREAM 08. The input data are included in **Appendix 7.2, Table A-7.2.7.5 to Table A-7.2.7.8.**

The results of the risk assessments for terrestrial reference organisms are shown in **Table 7.18** below and exceed the default ERICA screening value of 10 µGy/h. However, when the dose rates per organism is screened against 40 µGy/h the RQ 'expected' values and the conservative RQ values are less than 1.

Table 7.18: ERICA terrestrial organisms - screening value equal to 40 µGy/h

Organism	Total Dose Rate per organism (µGy/h)	Screening Value (µGy/h)	Risk Quotient (expected value) (unitless)	Risk Quotient (conservative value) (unitless)
Amphibian	1.04E+01	4.00E+01	2.60E-01	7.79E-01
Annelid	1.05E+01	4.00E+01	2.63E-01	7.90E-01
Arthropod - detritivorous	1.06E+01	4.00E+01	2.64E-01	7.93E-01
Bird	4.35E+00	4.00E+01	1.09E-01	3.26E-01
Flying insects	3.77E+00	4.00E+01	9.42E-02	2.83E-01
Grasses & Herbs	4.10E+00	4.00E+02	1.02E-02	3.07E-02
Lichen & Bryophytes	4.08E+00	4.00E+02	1.02E-02	3.06E-02
Mammal – large	6.67E+00	4.00E+01	1.67E-01	5.00E-01

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Organism	Total Dose Rate per organism ($\mu\text{Gy/h}$)	Screening Value ($\mu\text{Gy/h}$)	Risk Quotient (expected value) (unitless)	Risk Quotient (conservative value) (unitless)
Mammal - small-burrowing	1.09E+01	4.00E+01	2.71E-01	8.14E-01
Mollusc - gastropod	4.01E+00	4.00E+01	1.00E-01	3.01E-01
Reptile	9.70E+00	4.00E+01	2.42E-01	7.27E-01
Shrub	4.03E+00	4.00E+02	1.01E-02	3.02E-02
Tree	3.47E+00	4.00E+02	8.66E-03	2.60E-02

7.12 Uncertainties and Conservative Assumptions in the Dose Assessment for the Site

Any radiological assessment has associated uncertainties due to the models and parameter values adopted. The models are simplified representations of complex systems. These systems include the various environmental media that form the components of the radionuclide transfer paths, ending with human beings. In particular applications such as for detailed design assessments and optimisation studies, it may be necessary to quantify these uncertainties in more detail than was done in this site assessment. The dose assessment presented in this chapter adopted a cautious approach using conservative assumptions since the main objective is to demonstrate site suitability and not design optimisation.

A summary is provided of some of the main assumptions and uncertainties that feature in the dose assessment for the site.

7.12.1 Source Term

A bounding source term that was used is a representative of the maximum power generating capacity of 33 000 MW_{th} during a 60-year operating period of the NNPS. The average annual power level will be lower than this maximum value because of the sequential construction of reactor units and less than 100 per cent capacity factors as a result of refuelling outages, for example.

The radiological impact is dominated by the C-14 in the source term. The dose to the public and non-human species is highly sensitive to the chemical species of the discharged C-14 in the environment. In this site assessment,

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it was conservatively assumed that the chemical form is inorganic $^{14}\text{CO}_2$. All discharged C-14 therefore participates in the photosynthesis process, as opposed to organic chemical species. This assumption results in a high dose from ingestion pathways. However, the measured releases of gaseous C-14 from two U.S. and six German commercial pressurised water reactors found that the inorganic release fraction is on average 20 per cent and the organic release fraction is 80 per cent (EPRI, 1995). A more accurate assessment of the $^{14}\text{CO}_2$ fraction of the C-14 source terms should be available when an NNPS design selected for the site becomes available.

7.12.2 Dispersion in the Atmosphere

Following the release into the atmosphere of radioactive materials, the subsequent dispersion will depend on radionuclide properties and the meteorological conditions. The PLUME model was used for assessing the impact of continuous and routine discharges to the atmosphere. The endpoints of the calculations are long-term average or time-integrated concentrations in air, as is normally the case in the assessment of dose from continuous releases. The airborne discharges from multiple nuclear reactors of the NNPS were assumed to be from a single point at 10 m. These assumptions result in significantly higher radionuclide concentrations in the PIA than would be the case for multiple stacks discharging at much higher levels than 10 m. Assessment of a specific NNPS design in the next licensing phase will allow more realistic atmospheric dispersion assessments of discharges for routine as well as minor occurrences.

7.12.3 Dispersion in the Sea

It is assumed that the liquid discharge is from a single point into a local marine compartment of limited size as described in the *DORIS* model of *PC-CREAM 08*. There are, however, large uncertainties associated with the complex behaviour of radionuclides in different marine environments, e.g. sediment distribution coefficients (expressed as Bq/kg in sediment per Bq/l in seawater) and the radionuclide bioaccumulation and biomagnification in marine species at different trophic levels. Thermal dispersion studies in **Section 5.9** (Oceanography and Coastal Engineering) suggest that lower radioactivity concentrations in the local marine compartment can be expected when compared to the results calculated with *DORIS*. However, site-specific information will be required to calibrate the *DORIS* results and decrease uncertainties for the purpose of performing optimisation studies. Further information is provided in **Appendix 7.7** that will be considered in the next licensing phase and **Section 5.9** (Oceanography and Coastal Engineering). This report assumed a value for the volume exchange rate for the marine compartment, for which marine dispersion is highly sensitive, that is similar to the conservative value used for Duynefontyn (Eskom, 2022).

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7.12.4 Verification and Validation of Software

Verification and validation (V&V) reports for PC-Cream 08 have been submitted by Eskom and accepted by the NNR. The submission references are V&V Plan (k28065N) and PC-Cream QA Code Report (k29735N) (Eskom, 2024c).

An additional V&V report was prepared independent of the two reports prepared by Eskom. It includes the ERICA Tool software. ERICA Tool installation and benchmarking was checked by repeating a Tier 1 assessment carried out for the Westinghouse AP1000 as part of a generic design assessment in the UK (PSI, 2022). It is important to note that PC-CREAM 08 is used to assess public dose against the NNR regulatory dose constraint and limit values whereas ERICA Tool is used to assess non-human biota against international guidelines in respect of radiation dose/risk but not regulatory limits. This difference suggests a more detailed level of V&V in respect of PC-CREAM 08 when compared to requirements for ERICA Tool.

The ECOSYS software that was used to estimate the dose from minor occurrences is based on the ECOSYS module that forms part of PC COSYMA software of which the V&V has been accepted by the NNR. The PC COSYMA module FARMLAND has also been used in intercomparison studies at various stages of its development which included ECOSYS (IAEA, 1996). The dose results of the ECOSYS code were checked by referencing results of an alternative methodology for minor occurrences dose assessment ([Appendix 7.6](#)).

7.13 Monitoring

Monitoring of baseline environmental radioactivity prior to commissioning of the NNPS will be conducted. It will include further investigation of site-specific values for important parameters in the dose assessment model. This will be followed by ongoing monitoring of operational radionuclide discharges and levels of radioactivity in environmental media and food commodities.

Periodic surveys will be carried out on land and marine use and demographical changes and will include reviews of the data used for the characterisation of the representative person (NNR, 2019).

7.14 Management System

The PRIPE investigations performed in this SSR entailed the following:

- review of documents of national and international authorities that address assessments of radiological dose and health consequences;

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- derivation of a bounding source term for annual airborne and liquid discharges based on the selection of the reference GEN III reactor technology considered by Eskom;
- review of exposure pathways and public habits data to define a representative person for public dose assessment;
- determination of compliance with NNR regulations.

The PRIPE assessment was carried out within the framework of the overall management system for this SSR; **Chapter 10** (Management System), national regulations and international guidelines as outlined in **Subsection 7.2**.

The following documents were compiled by the consultant and accepted by Eskom to assist in quality assurance and to present a clear and auditable trail showing how key decisions were made and conclusions reached:

- SRK's Integrated Quality Management System and associated Work Instructions;
- the project-specific Project Quality Plan;
- PRIPE technical specification and methodology documents;
- Quality Control Plan;
- project process chart.

Input data to PRIPE also rely on the KNPS quality management system. This conforms to the overall management system for this SSR, national regulations, international guidelines as outlined in documents of national authorities and relevant Eskom classification procedures. **Table 7.19** lists the activities carried out, the links to other SSR sections/chapters and the relevant quality control requirements.

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Table 7.19: Summary of Activities, Links and Quality Requirements

Activity	Links		Quality Requirements
	Inputs	Outputs	
Obtain meteorological data	<u>Section 5.8</u> (Meteorology).	<u>Chapter 7</u> (PRIPE). Atmospheric dispersion and dose compliance assessment.	Review by Section 5.8 Meteorology Subject Matter Expert
Obtain habits data and related demography	<u>Section 5.4</u> (Demography). <u>Section 5.5</u> (Land and Water Use) <u>Section 5.6</u> (Adjacent Sea Use)	<u>Chapter 7</u> (PRIPE). Define the representative person for the site and dose compliance assessment.	Eskom review.
Obtain data on non-human biota (terrestrial and marine organisms)	<u>Section 5.3</u> (Ecology) <u>Section 5.5</u> (Land and Water Use) <u>Section 5.6</u> (Adjacent Sea Use)	<u>Chapter 7</u> (PRIPE) Non-human biota screening dose rate assessment	Eskom review.
Demonstrate compliance with regulatory requirements	<u>Chapter 2</u> (Legal and Regulatory Basis).	<u>Chapter 7</u> (PRIPE). Dose compliance assessment.	Eskom review.

A regulatory compliance table is presented in **Table 7.20** which indicates the relevant issues that have been dealt with in this section.

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Table 7.20: Regulatory Compliance Matrix

Act/Regulation	Section/Regulation	Issue	Section Where Covered
Regulations on Siting of New Nuclear Installations	Regulation 5 (6)	Assessment of potential impact of operations on public exposure. Demonstrate compliance with regulatory dose criteria	7.2, 7.10
Regulation R. 388	Regulation 5(5)	Annual effective dose limit to members of the public	7.3
Regulation R. 388	Regulation 1(2)(xvii)	Dose constraints	7.3; 7.10.4
Regulation R. 388	Regulation 1(2)(xiv)	Source terms and discharges	7.3; 7.10
Requirements Document RD-0034	Section 7	Management systems	7.14

7.15 Conclusions

The potential annual dose values for members of the public were determined using habits survey data collected during the first quarter of 2024 to define the current characteristics of a representative person (PSI, 2024). Categories of exposure pathways that were assessed were as follows:

- normal and routine airborne and liquid discharges;
- minor occurrences and their short-term contingency discharges;
- direct external gamma radiation from NNPS buildings.

The representative person total annual dose is estimated to be 171.52 $\mu\text{Sv/y}$.

It is concluded that NNPS on the site generating a maximum of 33 000 MW_{th} will comply with NNR regulatory public dose limit and dose constraint values of 1000 $\mu\text{Sv/y}$ and 250 $\mu\text{Sv/y}$.

The results of radio-ecological screening assessment indicate no significant radiological impact on non-human species. None of the organisms included

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as representative species in the *ERICA* code exceed the screening value of 10 µGy/h.

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Appendix 7.1: Environmental Modelling of Radioactive Discharges During Normal Operations – An Overview of PC-CREAM 08

This appendix outlines the methodology, *CREAM* (Consequences of Releases to the Environment Assessment Methodology), for the assessment of the radiological consequences of routine releases of radioactive effluents as applied in the computer system, *PC-CREAM 08* (UK HPA, 2009).

The first version of *PC-CREAM*, which was completed in 1997, was a PC implementation of a main frame program for the assessment of radiation doses resulting from routine nuclear installation discharges of radionuclides to the environment. The program was originally designed for use in European countries, where it has been widely used, but copies have also been sold to many other countries world-wide. As a result, there has been considerable feedback from users through training courses and user group meetings regarding many aspects of the system. In response to this feedback and to recent model developments, a revised version of the software has been developed. This new version of *PC-CREAM* known as *PC-CREAM 08* has been used for this site feasibility assessment.

The program has been significantly improved in comparison with earlier versions. It can be used to estimate individual and collective doses arising from discharges of radionuclides to the atmosphere and aquatic environments. It is particularly useful for performing prospective assessments as input to discharge authorisations.

PC-CREAM 08 is a complex model that is divided into several parts for ease of use. The main division of the program is into 'Models' and 'ASSESSOR'. The Models part includes a series of mathematical models that predict the transfer of radionuclides through the environment and provide estimates of activity concentrations in various environmental media following a continuous discharge. The output of these models is then used as input to the dose assessment part of the program *ASSESSOR*. Exposures to humans can be compared with the dose limits or constraints as required by regulatory criteria.

The models represent the transfer of a wide range of radionuclides through atmospheric, terrestrial and aquatic pathways. These models enable the spatial and temporal distribution of radioactivity in the environment to be predicted. Default values have been given for many parameters and have been used to determine illustrative results. The choice of such values is necessarily a compromise taking into account the range of possible values. For specific sites and applications, it will often be appropriate to choose alternative values. The models adopted in *CREAM* are those considered appropriate for routine releases. They have generally been subject to extensive verification and validation.

An overview of each of the models included within *PC-CREAM 08* and the dose assessment part of the program is given in the following sections.

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PLUME

PLUME is the atmospheric dispersion model used within *PC-CREAM 08*. It is a Gaussian plume model and accounts for the meteorological conditions during the discharge; the roughness of the land surface and the physical characteristics of the radionuclides being discharged. The model calculates activity concentrations in air, deposition rates and external gamma dose rates from radionuclides in the cloud (cloud gamma) at various distances downwind of the discharge point. The output from the model can be used as input to *ASSESSOR* which combines these results with site-specific meteorological data and actual discharge rates to calculate actual activity concentrations in air, deposition rates and cloud gamma dose rates downwind of the discharge point. The deposition rates from *PLUME* are used to scale the results from the other models, namely *RESUS*, *GRANIS* and *FARMLAND*, to estimate doses from various exposure routes arising from the discharge of radionuclides to the atmosphere.

RESUS

RESUS can be used to estimate activity concentrations in air arising from the re-suspension of previously deposited radionuclides. The activity concentrations, which are calculated for a user-defined deposition rate, are input to *ASSESSOR* which scales them by the actual deposition rate at various locations downwind of the discharge point and combines them with habit data to calculate doses from inhalation of re-suspended material.

GRANIS

External exposure to gamma radiation from radionuclides deposited on the ground is calculated using the *GRANIS* model. *GRANIS* models the transfer of radionuclides through the soil and takes into account the shielding properties of the soil when estimating doses one metre above the soil surface. The doses are calculated based on a user-defined deposition rate. *GRANIS* is the only model in *PC-CREAM 08* that includes some organ doses as well as effective dose. Effective doses are input to *ASSESSOR* which scales them by the actual deposition rate at various locations downwind of the discharge point and combines them with habit data to estimate actual exposures.

FARMLAND

FARMLAND is a suite of models that can be used to predict the transfer of radionuclides into terrestrial foods following deposition onto the ground. The food categories considered are those that are most important in the human diet, namely, green vegetables, root vegetables, fruit, grain, cow milk, cow milk products, beef, cattle liver, mutton, and sheep liver. Activity

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concentrations in each food are calculated for a user-defined deposition rate. These activity concentrations are input to *ASSESSOR* which scales them by the actual deposition rate at various locations downwind of the discharge point and combines them with habit data to calculate ingestion doses.

DORIS

The marine dispersion model used in *PC-CREAM 08* is based closely on the *MARINA II* model. The model can be used to predict the activity concentrations in sea water, sediments and marine biota for user-defined discharge rates. These activity concentrations are input to *ASSESSOR* which scales them by the actual discharge rate and combines them with habit data to calculate doses from ingestion of marine foods, external exposure to beach sediments and inhalation of sea spray.

RIVER

PC-CREAM 08 includes two models for calculating the dispersion of radionuclides released to rivers. The *Screening model* is a simple dilution model, which assumes instantaneous equilibrium between the water and river sediments and should be used as a screening tool. It can be used in three modes depending on the amount of input data available. For more detailed assessments the *Dynamic model* can be used which is a time dependent compartment model and requires a greater amount of input data to run. The models are used for non-coastal sites such as the NPPs located on the main rivers in Europe. The *River model* is of no interest to the KNPS application.

ASSESSOR

Once activity concentrations in environmental media have been calculated using the various models they can be used in *ASSESSOR*, the dose assessment part of *PC-CREAM 08*, to calculate effective doses. There are five parts of *ASSESSOR* to calculate individual and collective doses from discharges to the atmosphere and sea and individual doses from discharges into rivers. Each part of *ASSESSOR* displays all the model runs that are available for use including the default set. The results of these models are combined with actual discharge rates, site-specific data, habit data and dose coefficients to calculate effective doses for the most important exposure pathways. The dose coefficients used are provided in data tables.

To calculate external effective dose from exposure to beta radiation in the plume (cloud beta) *ASSESSOR* uses a set of dose coefficients that give the skin equivalent dose rate per unit air concentration assuming total immersion in the contaminated air. Similarly, the external effective dose from exposure to beta radiation on the ground (deposited from atmosphere or as part of

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aquatic sediments) is calculated using a set of dose coefficients that give the skin equivalent dose rate per unit deposition at 80 cm above a uniformly contaminated surface. A slightly different approach is used to estimate the external beta and gamma exposures to radionuclides in contaminated fishing gear; these are calculated using empirical formulae and the mean energy of the beta and gamma radiation. The same mean gamma energies are also used to calculate the external gamma dose above aquatic sediments.

The radiological consequences of routine releases of radionuclides are determined using the framework of the system of dose limitation recommended by the International Commission on Radiological Protection (ICRP). The recommendations of ICRP have been issued in Publication 60 (ICRP, 1991). ICRP has since published updated recommendations in Publication 103 and the impact of these have been considered. At the levels of individual dose typically encountered from routine discharge, only the stochastic effects of radiation needed to be considered. These comprise fatal and non-fatal cancers in the exposed population and hereditary effects in its descendants.

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Appendix 7.2: Non-human Biota Dose – ERICA Assessment Tool Input Data

Table A-7.2.7.1: Seabed sediment and unfiltered seawater radioactivity per unit liquid nuclide discharge calculated with DORIS

Radionuclide Note: Nuclides identified by an asterisk (*) are progeny of a preceding nuclide.	Seabed sediment (Bq/kg)	Unfiltered seawater (Bq/L)
Ag-110	1.10E-21	5.63E-18
Ag-110m	3.69E-11	2.26E-13
Ba-137m	1.91E-20	3.50E-17
Ba-140	4.84E-13	1.24E-13
La-140*	6.69E-13	1.08E-13
Br-82	7.24E-15	2.60E-14
Br-83	3.69E-17	1.95E-15
Br-84	1.82E-18	4.36E-16
C-14	1.90E-10	2.50E-13
Ce-141	5.58E-12	1.70E-13
Ce-143	3.40E-14	2.43E-14
Pr-143	1.89E-13	1.13E-14
Ce-144	6.08E-11	2.23E-13
Co-58	1.39E-11	1.98E-13
Co-60	3.25E-10	2.34E-13
Cr-51	4.17E-12	1.63E-13
Cs-134	7.19E-11	2.38E-13
Cs-136	7.59E-13	1.25E-13
Cs-137	3.73E-10	2.47E-13
Cs-138	4.60E-18	4.41E-16

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Radionuclide Note: Nuclides identified by an asterisk (*) are progeny of a preceding nuclide.	Seabed sediment (Bq/kg)	Unfiltered seawater (Bq/L)
Fe-55	1.77E-10	2.32E-13
Fe-59	7.53E-12	1.84E-13
H-3	4.28E-13	2.49E-13
I-129	1.32E-11	2.50E-13
I-130	1.88E-16	9.78E-15
I-131	2.90E-14	9.70E-14
Xe-131m	3.10E-14	5.00E-14
I-132	6.74E-18	1.88E-15
I-132m	2.48E-18	1.14E-15
I-132	6.55E-18	1.13E-15
I-133	5.20E-16	1.60E-14
Xe-133	1.64E-15	1.13E-14
I-134	9.84E-19	7.20E-16
I-135	5.49E-17	5.33E-15
Xe-135*	1.00E-16	5.17E-15
Cs-135	1.63E-19	7.77E-23
La-140	4.94E-14	2.90E-14
Mn-54	6.67E-11	2.23E-13
Mo-99	1.12E-13	4.40E-14
Tc-99m*	1.13E-13	4.32E-14
Tc-99*	3.11E-18	7.11E-21
Na-24	1.71E-16	1.18E-14

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Radionuclide Note: Nuclides identified by an asterisk (*) are progeny of a preceding nuclide.	Seabed sediment (Bq/kg)	Unfiltered seawater (Bq/L)
Nb-95*	6.12E-12	1.73E-13
Nd-147	1.22E-12	1.12E-13
Pm-147*	2.14E-12	1.38E-15
Sm-147*	2.76E-22	4.56E-27
Ni-59	9.41E-10	2.49E-13
Ni-63	8.36E-10	2.47E-13
Np-239	1.75E-14	3.91E-14
Pu-239*	2.62E-16	5.62E-20
U-235*	3.77E-24	7.02E-29
Pa-231*	1.20E-27	1.81E-32
Ac-227*	3.57E-28	5.36E-33
Ra-223*	3.55E-28	5.51E-33
Pb-211*	3.55E-28	5.51E-33
Bi-211*	3.55E-28	5.51E-33
Tl-207*	3.55E-28	5.51E-33
P-32	8.11E-14	1.32E-13
Pr-143	1.71E-12	1.24E-13
Pr-144	2.89E-18	2.37E-16
Pu-241	5.89E-10	2.40E-13
Am-241	1.73E-11	2.77E-16
Np-237*	7.61E-17	1.37E-21

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Radionuclide Note: Nuclides identified by an asterisk (*) are progeny of a preceding nuclide.	Seabed sediment (Bq/kg)	Unfiltered seawater (Bq/L)
U-233*	3.94E-21	7.07E-26
Th-229*	4.30E-24	6.47E-29
Ac-225*	4.29E-24	6.45E-29
Bi-213*	4.29E-24	6.45E-29
Pb-209*	4.29E-24	6.45E-29
Rb-86	1.26E-12	1.46E-13
Rb-88	1.41E-18	2.44E-16
Rh-103m	2.39E-18	7.68E-16
Rh-106	1.89E-22	6.84E-18
Ru-103	6.34E-12	1.79E-13
Ru-106	7.04E-11	2.26E-13
Sb-122	2.24E-14	4.39E-14
Sb-124	2.30E-12	2.04E-13
Sb-125	3.76E-11	2.44E-13
Te-125m	3.75E-11	4.37E-14
Sr-89*	2.09E-13	2.00E-13
Sr-90	1.67E-12	2.50E-13
Sr-91	7.59E-17	7.59E-15
Y-91m	3.40E-16	7.56E-15
Y-91	7.41E-14	1.26E-15
Sr-92	6.32E-18	2.21E-15

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Radionuclide Note: Nuclides identified by an asterisk (*) are progeny of a preceding nuclide.	Seabed sediment (Bq/kg)	Unfiltered seawater (Bq/L)
Y-92	3.33E-16	2.18E-15
Tc-99m	5.27E-17	4.86E-15
Tc-99*	6.16E-20	7.91E-22
Te-123m	4.92E-12	2.23E-13
Te-123*	6.10E-24	8.70E-28
Te-125m*	2.20E-12	2.03E-13
Te-127*	5.51E-16	7.47E-15
Te-129	8.72E-18	9.52E-16
I-129	1.13E-22	2.10E-24
Te-129m	1.13E-12	1.80E-13
I-129	3.00E-19	4.08E-22
Te-131	1.13E-18	3.43E-16
I-131	6.37E-17	2.09E-16
Xe-131m	6.76E-17	1.08E-16
Te-131m	5.32E-15	2.25E-14
I-131	9.39E-15	1.37E-14
Xe-131m	8.18E-15	7.07E-15
Te-132	3.15E-14	5.11E-14
I-132	3.17E-14	5.07E-14
Te-133m	5.53E-18	7.58E-16
I-133	2.85E-17	7.09E-16
Xe-133	7.74E-17	5.01E-16

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Radionuclide Note: Nuclides identified by an asterisk (*) are progeny of a preceding nuclide.	Seabed sediment (Bq/kg)	Unfiltered seawater (Bq/L)
Te-134	3.15E-18	5.72E-16
I-134	3.93E-18	5.71E-16
W-187	1.58E-14	1.82E-14
Re-187*	5.69E-24	1.26E-26
Y-91*	1.13E-11	1.93E-13
Y-91m	2.38E-17	6.80E-16
Y-91	6.66E-15	1.13E-16
Y-92*	4.30E-16	2.88E-15
Y-93	3.42E-15	8.03E-15
Zr-93	8.81E-19	1.81E-22
Nb-93m	4.32E-19	6.88E-24
Zn-65	4.91E-11	2.22E-13
Zr-95	1.25E-11	1.95E-13
Nb-95	1.41E-11	4.89E-14

DORIS Reference File: **Note that in the same file you will have a drop down where you will select either the Seabed sediment or unfiltered seawater results.**

CREAM Table CSV file
PC CREAM Version: 1.5.1.92
Database Version: 2.0.0 Update Version
Assessment Name: TSSR Update_DORIS04
Description: TSSR Update 24 ST from DSSR NNPS_Original local box dimensions
Last updated: 31 10 2024 15:53

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Table A-7.2.7.2: Max Liquid Source Term Derived From NNPS

Nuclide	Bq/y	Nuclide	Bq/y
Na-24	5.83E+08	Np-239	6.75E+07
P-32	5.52E+07	Pu-241	7.73E+05
Cr-51	4.34E+09	Rb-86	2.38E+06
Mn-54	1.98E+09	Rb-88	3.77E+06
Fe-55	4.73E+09	Sr-89	4.91E+07
Fe-59	7.36E+08	Sr-90	6.75E+06
Co-58	1.52E+10	Sr-91	7.97E+06
Co-60	2.20E+10	Sr-92	1.73E+02
Ni-63	7.04E+09	Y-91	2.76E+07
Zn-65	1.08E+08	Y-91m	5.21E+06
Br-83	5.07E+04	Y-93	8.87E+06
Br-82	1.00E+04	Zr-95	3.99E+08
Br-84	8.77E+03	Nb-95	6.44E+08
W-187	4.29E+07	Mo-99	2.33E+08
Tc-99m	1.74E+08	Ba-140	1.38E+09
Ru-103	1.19E+09	La-140	1.50E+09
Rh-103m	1.14E+09	Ce-141	9.20E+07
Ru-106	2.18E+10	Ce-143	5.83E+07
Rh-106	1.90E+10	Ce-144	2.02E+09
Ag-110m	4.18E+09	Pr-143	2.00E+07
Ag110	3.37E+07	Pr-144	8.28E+08
I-129	1.29E+01	Te-123m	1.91E+09
I-130	2.80E+04	Te-125m	1.17E+05

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Nuclide	Bq/y	Nuclide	Bq/y
I-132m	2.44E+03	Te-127	3.06E+03
I-131	8.28E+08	Te-129m	2.70E+07
I-132	2.21E+08	Te-129	1.90E+07
I-133	1.04E+09	Te-131m	3.03E+07
I-134	5.70E+07	Te-131	5.52E+06
H-3	9.81E+14	Te-132	6.13E+07
Cs-134	4.10E+09	Te-133m	2.14E+05
I-135	7.05E+08	Te-134	2.38E+03
Cs-136	1.19E+09	Sb-124	3.59E+09
Cs-137	6.93E+09	Sb-122	1.26E+07
Cs-138	6.40E+04	Sb-125	5.97E+09
Ba-137m	1.28E+08	C-14	6.96E+11

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Table A-7.2.7.3: ERICA Environmental Media Concentration Limits (EMCL) and reference marine organisms

Radionuclide	EMCL (Bq/L)	Limiting organism
Ac-228	2.13E-03	Polychaete worm
Ag-110m	6.21E-02	Polychaete worm
Am-241	5.35E-04	Phytoplankton
At-218	5.32E+01	Polychaete worm
Ba-137m	1.57E+00	Polychaete worm
Ba-140	3.65E-01	Polychaete worm
Bi-210	1.60E+00	Polychaete worm
Bi-212	4.15E-02	Polychaete worm
Bi-214	3.73E-02	Polychaete worm
C-14	1.52E+01	Bird
Ca-45	4.31E+02	Phytoplankton
Cd-109	3.41E-01	Sea anemones & True coral
Ce-141	7.58E-03	Polychaete worm
Ce-144	1.71E-03	Polychaete worm
Cf-252	2.22E-04	Phytoplankton
Cl-36	1.59E+04	Vascular plant
Cm-242	4.39E-04	Phytoplankton
Cm-243	4.37E-04	Phytoplankton
Cm-244	4.39E-04	Phytoplankton
Co-57	4.76E-02	Polychaete worm
Co-58	5.92E-03	Polychaete worm
Co-60	2.30E-03	Polychaete worm

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Radionuclide	EMCL (Bq/L)	Limiting organism
Cr-51	1.10E+00	Polychaete worm
Cs-134	2.86E-01	Polychaete worm
Cs-135	1.36E+02	Reptile
Cs-136	2.10E-01	Polychaete worm
Cs-137	7.75E-01	Polychaete worm
Eu-152	7.35E-04	Polychaete worm
Eu-154	6.85E-04	Polychaete worm
H-3	4.26E+05	Crustacean
I-125	1.99E+01	Macroalgae
I-129	9.43E+00	Macroalgae
I-131	9.09E+00	Macroalgae
I-132	1.13E+01	Polychaete worm
I-133	1.72E+01	Macroalgae
Ir-192	2.28E-02	Polychaete worm
La-140	2.51E-04	Polychaete worm
Mn-54	1.10E-03	Polychaete worm
Nb-94	1.36E-03	Polychaete worm
Nb-95	2.78E-03	Polychaete worm
Ni-59	1.17E+02	Polychaete worm
Ni-63	1.05E+02	Polychaete worm
Np-237	1.05E-02	Vascular plant
P-32	1.36E-01	Crustacean
P-33	8.40E-01	Crustacean

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Radionuclide	EMCL (Bq/L)	Limiting organism
Pa-231	1.52E-04	Phytoplankton
Pa-234m	2.15E-03	Polychaete worm
Pb-210	4.00E-04	Phytoplankton
Pb-212	3.38E-03	Phytoplankton
Pb-214	9.09E-03	Polychaete worm
Po-210	4.42E-04	Polychaete worm
Po-212	2.97E+09	Polychaete worm
Po-214	7.04E-02	Polychaete worm
Po-216	5.52E-05	Polychaete worm
Po-218	4.69E-05	Polychaete worm
Pu-238	8.33E-04	Phytoplankton
Pu-239	8.85E-04	Phytoplankton
Pu-240	8.85E-04	Phytoplankton
Pu-241	7.94E-01	Phytoplankton
Ra-224	1.07E-01	Phytoplankton
Ra-226	3.21E-02	Phytoplankton
Ra-228	1.49E-01	Phytoplankton
Rh-106	3.25E-02	Polychaete worm
Ru-103	8.55E-02	Polychaete worm
Ru-106	6.94E-02	Polychaete worm
S-35	4.63E+04	Vascular plant
Sb-124	4.74E-01	Polychaete worm
Sb-125	2.04E+00	Polychaete worm

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Radionuclide	EMCL (Bq/L)	Limiting organism
Se-75	1.54E+00	Polychaete worm
Se-79	2.42E+01	Mammal
Sr-89	8.00E+01	Mammal
Sr-90	2.64E+01	Mammal
Tc-99	9.90E-01	Macroalgae
Te-129m	3.17E+00	Phytoplankton
Te-132	7.14E-01	Polychaete worm
Th-227	3.83E-05	Phytoplankton
Th-228	2.58E-05	Phytoplankton
Th-230	1.72E-04	Phytoplankton
Th-231	3.14E-02	Polychaete worm
Th-232	1.92E-04	Phytoplankton
Th-234	3.39E-03	Polychaete worm
Tl-208	8.47E-02	Polychaete worm
U-234	2.06E-01	Polychaete worm
U-235	2.20E-01	Polychaete worm
U-237	1.32E+01	Polychaete worm
U-238	2.29E-01	Polychaete worm
Y-90	3.48E-02	Polychaete worm
Zn-65	4.22E-02	Polychaete worm
Zr-95	5.99E-04	Polychaete worm

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Table A-7.2.7.4: Marine radioactivity concentrations

Nuclide	Activity Concentration in sediment (Bq/kg]	Activity Concentration in unfiltered seawater (Bq/L)
Ag-110m	3.69E-11	9.45E-04
Ba-137m	1.91E-20	4.48E-09
C-14	1.90E-10	1.74E-01
Ce-144	6.08E-11	4.50E-04
Co-58	1.39E-11	3.01E-03
Co-60	3.25E-10	5.15E-03
Cr-51	4.17E-12	7.07E-04
Cs-134	7.19E-11	9.76E-04
Cs-137	3.73E-10	1.71E-03
Fe-55	1.77E-10	1.10E-03
Fe-59	7.53E-12	1.35E-04
H-3	4.28E-13	2.44E+02
I-131	2.90E-14	8.03E-05
La-140	4.94E-14	4.35E-05
Mn-54	6.67E-11	4.42E-09
Mo-99	1.12E-13	1.03E-05
Ni-63	8.36E-10	1.74E-03
Nb-95	6.12E-12	1.11E-04
Rh-106	1.89E-22	1.30E-07
Ru-106	7.04E-11	4.93E-03
Sb-124	2.24E-14	7.32E-04

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Nuclide	Activity Concentration in sediment (Bq/kg]	Activity Concentration in unfiltered seawater (Bq/L)
Tc-99m	5.27E-17	8.46E-07
Zr-95	1.25E-11	7.78E-05

Table A-7.2.7.5: EMCL values for soil or for H and C in air in a generic terrestrial ecosystem based on the ERICA Screening dose rate of 10 µGy/h

Radionuclide	EMCL (Bq kg ⁻¹ d.w.)	Limiting organism
Ac-228	4.83E+03	Lichen & Bryophytes
Ag-110m	3.68E+03	Grasses & Herbs
Am-241	7.46E+01	Lichen & Bryophytes
At-218	1.30E+04	Arthropod - detritivorous
Ba-137m	3.10E+04	Arthropod - detritivorous
Ba-140	3.89E+03	Bird
Bi-210	1.13E+04	Tree
Bi-212	1.47E+04	Arthropod - detritivorous
Bi-214	1.30E+04	Arthropod - detritivorous
C-14	8.33E+01	Tree
Ca-45	2.12E+03	Mammal - small-burrowing
Cd-109	1.23E+04	Annelid
Ce-141	3.14E+05	Reptile
Ce-144	9.80E+04	Bird
Cf-252	3.98E+01	Lichen & Bryophytes
Cl-36	1.06E+03	Grasses & Herbs
Cm-242	8.55E+01	Lichen & Bryophytes

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Radionuclide	EMCL (Bq kg ⁻¹ d.w.)	Limiting organism
Cm-243	7.58E+01	Lichen & Bryophytes
Cm-244	7.63E+01	Lichen & Bryophytes
Co-57	1.63E+05	Annelid
Co-58	1.86E+04	Annelid
Co-60	7.41E+03	Annelid/Arthropod - detritivorous
Cr-51	6.25E+05	Arthropod - detritivorous
Cs-134	1.53E+03	Mammal - large
Cs-135	1.49E+04	Lichen & Bryophytes
Cs-136	3.51E+03	Mammal - large
Cs-137	2.76E+03	Mammal - large
Eu-152	1.66E+04	Amphibian
Eu-154	1.51E+04	Amphibian
H-3	2.87E+03	Tree
I-125	6.99E+05	Arthropod - detritivorous
I-129	3.44E+05	Arthropod - detritivorous
I-131	4.88E+04	Arthropod - detritivorous
I-132	8.26E+03	Arthropod - detritivorous
I-133	2.93E+04	Arthropod - detritivorous
Ir-192	1.80E+03	Tree
La-140	8.40E+03	Annelid/Arthropod - detritivorous
Mn-54	7.69E+03	Tree
Nb-94	1.12E+04	Annelid

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Radionuclide	EMCL (Bq kg ⁻¹ d.w.)	Limiting organism
Nb-95	2.38E+04	Arthropod - detritivorous
Ni-59	1.09E+06	Reptile
Ni-63	8.33E+05	Reptile
Np-237	9.17E+01	Lichen & Bryophytes
P-32	8.47E+02	Mammal - large
P-33	5.32E+03	Mammal - large
Pa-231	8.55E+01	Lichen & Bryophytes
Pa-234m	1.04E+06	Arthropod - detritivorous
Pb-210	7.58E+01	Lichen & Bryophytes
Pb-212	1.80E+03	Lichen & Bryophytes
Pb-214	1.07E+04	Arthropod - detritivorous
Po-210	5.18E+01	Lichen & Bryophytes
Po-212	3.47E+14	Lichen & Bryophytes
Po-214	1.56E+08	Arthropod - detritivorous
Po-216	1.36E+04	Arthropod - detritivorous
Po-218	1.12E+04	Arthropod - detritivorous
Pu-238	7.35E+02	Lichen & Bryophytes
Pu-239	7.81E+02	Lichen & Bryophytes
Pu-240	7.81E+02	Lichen & Bryophytes
Pu-241	7.04E+05	Lichen & Bryophytes
Ra-224	1.81E+02	Shrub
Ra-226	2.82E+01	Lichen & Bryophytes

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Radionuclide	EMCL (Bq kg ⁻¹ d.w.)	Limiting organism
Ra-228	1.30E+02	Lichen & Bryophytes
Rh-106	9.09E+04	Arthropod - detritivorous
Ru-103	1.14E+04	Annelid
Ru-106	1.23E+03	Annelid
S-35	9.43E+03	Mammal - large
Sb-124	6.10E+03	Annelid
Sb-125	1.60E+04	Annelid
Se-75	2.81E+04	Mammal - large
Se-79	3.51E+04	Annelid
Sr-89	5.24E+03	Lichen & Bryophytes
Sr-90	2.05E+03	Lichen & Bryophytes
Tc-99	4.02E+03	Grasses & Herbs
Te-129m	6.49E+03	Annelid
Te-132	6.25E+03	Annelid
Th-227	1.00E+02	Lichen & Bryophytes
Th-228	4.08E+01	Lichen & Bryophytes
Th-230	2.65E+02	Lichen & Bryophytes
Th-231	1.10E+06	Grasses & Herbs
Th-232	2.96E+02	Lichen & Bryophytes
Th-234	5.95E+04	Grasses & Herbs
Tl-208	5.78E+03	Arthropod - detritivorous
U-234	1.14E+02	Lichen & Bryophytes

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Radionuclide	EMCL (Bq kg ⁻¹ d.w.)	Limiting organism
U-235	1.23E+02	Lichen & Bryophytes
U-237	2.14E+05	Arthropod - detritivorous
U-238	1.28E+02	Lichen & Bryophytes
Y-90	3.50E+06	Lichen & Bryophytes
Zn-65	5.56E+03	Mammal - large
Zr-95	1.25E+04	Arthropod - detritivorous

Note: Table A-7.2.7.6 provides a measure of each nuclide's relative importance in airborne discharges. C-14 is assigned an importance factor of '1' based on its total source term activity and EMCL value; it has the lowest ERICA EMCL value based on its highest organism dose per unit activity. Nuclides with a relative importance less than 1E-06 are not included in the dose assessment and their doses to terrestrial reference organisms are trivial. Nuclides that were included in the dose assessment are in italic format (down to Co-60).

Table A-7.2.7.6: Nuclide relative importance weighted against nuclide activity and C-14 EMCL (terrestrial organisms)

Radionuclide	Max ST (NNPS) Bq/y	EMCL Bq/kg	Nuclide relative importance weighted against nuclide activity and C-14 EMCL
<i>H-3</i>	<i>5.37E+13</i>	<i>2.87E+03</i>	<i>9.80E-02</i>
<i>C-14</i>	<i>1.59E+13</i>	<i>8.33E+01</i>	<i>1.00E+00</i>
<i>Co-58</i>	<i>6.36E+08</i>	<i>1.86E+04</i>	<i>1.79E-07</i>
<i>I-133</i>	<i>7.05E+09</i>	<i>2.93E+04</i>	<i>1.26E-06</i>
<i>I-132</i>	<i>1.48E+10</i>	<i>8.26E+03</i>	<i>9.39E-06</i>
<i>I-131</i>	<i>1.84E+09</i>	<i>4.88E+04</i>	<i>1.98E-07</i>
<i>Ag-110m</i>	<i>2.96E+06</i>	<i>3.68E+03</i>	<i>4.21E-09</i>
<i>Sr-89</i>	<i>4.91E+07</i>	<i>5.24E+03</i>	<i>4.91E-08</i>

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Radionuclide	Max ST (NNPS) Bq/y	EMCL Bq/kg	Nuclide relative importance weighted against nuclide activity and C-14 EMCL
<i>Cs-134</i>	<i>5.83E+08</i>	<i>1.53E+03</i>	<i>2.00E-06</i>
<i>Sb-124</i>	<i>5.99E+05</i>	<i>6.10E+03</i>	<i>5.14E-10</i>
<i>Co-60</i>	<i>7.48E+08</i>	<i>7.41E+03</i>	<i>5.29E-07</i>
Cs-137	5.23E+08	2.76E+03	9.93E-07
Nb-95	1.28E+07	2.38E+04	2.82E-09
Mn-54	1.75E+07	7.69E+03	1.19E-08
Cs-136	1.01E+07	3.51E+03	1.51E-08
Ni-63	1.55E+07	8.33E+05	9.75E-11
Cr-51	5.52E+03	6.25E+05	4.63E-14
Sr-90	1.93E+07	2.05E+03	4.93E-08
Sb-125	1.87E+05	1.60E+04	6.12E-11
I-129	1.52E+08	3.44E+05	2.32E-09
Ru-103	5.21E+06	1.14E+04	2.39E-09
Ba-140	1.55E+06	3.89E+03	2.09E-09
Zr-95	3.57E+06	1.25E+04	1.50E-09
La-140	4.49E+02	8.40E+03	2.80E-13
Ru-106	2.40E+05	1.23E+03	1.02E-09
Te-129m	1.37E+05	6.49E+03	1.11E-10
Co-57	2.51E+06	1.63E+05	8.07E-11
Ce-141	3.99E+06	3.14E+05	6.66E-11
Te-132	3.39E+04	6.25E+03	2.84E-11

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Table A-7.2.7.7: Nuclide soil radioactivity concentration based on deposition of airborne discharges

Radionuclide	Max ST (NNPS) Bq/y	Deposition, Bq/m ² -s	Soil concentration per unit volume, Bq/m ³	Soil density kg/m ³	Soil concentration per unit mass, Bq/kg	EMCL Bq kg ⁻¹ d.w.
Co-58	6.36E+08	1.35E-16	3.22E+09	1.30E+00	2.13E+02	1.86E+04
Co-60	7.48E+08	1.35E-16	8.31E+10	1.30E+00	6.45E+03	7.41E+03
Sr-89	4.91E+07	1.35E-16	2.29E+09	1.30E+00	1.17E+01	5.24E+03
Ag-110m	2.96E+06	1.35E-16	1.13E+10	1.30E+00	3.47E+00	3.68E+03
Sb-124	5.99E+05	1.35E-16	2.74E+09	1.30E+00	1.70E-01	6.10E+03
I-131	1.84E+09	1.10E-15	3.66E+08	1.30E+00	5.70E+02	4.88E+04
I-132	1.48E+10	1.04E-15	4.36E+06	1.30E+00	5.16E+01	8.26E+03
I-133	7.05E+09	1.10E-15	3.94E+07	1.30E+00	2.35E+02	2.93E+04
Cs-134	5.83E+08	1.35E-16	3.36E+10	1.30E+00	2.03E+03	1.53E+03

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Table A-7.2.7.8: Nuclide Soil Activity Calculated with GRANIS as integrated Activity Concentrations in Soil Layers (Bq d/m²) for Deposition Rate over One Year of 1 Bq/m²/s

Radionuclide and soil depth	Time (y)			
	1	40	60	80
Ag-110m				
0m – 0.3m	4.21E+09	1.13E+10	1.13E+10	1.13E+10
		Bq/m³ =	1.13E+10	
Co-58				
0m – 0.3m	2.34E+09	3.22E+09	3.22E+09	3.22E+09
		Bq/m³ =	3.22E+09	
Co-60				
0m – 0.3m	5.50E+09	8.28E+10	8.31E+10	8.31E+10
		Bq/m³ =	8.31E+10	
Cs-134				
0m – 0.3m	5.15E+09	3.36E+10	3.36E+10	3.36E+10
		Bq/m³ =	3.43E+10	
I-131				
0m – 0.3m	3.54E+08	3.66E+08	3.66E+08	3.66E+08
		Bq/m³ =	3.66E+08	
I-132				
0m – 0.3m	4.36E+06	4.36E+06	4.36E+06	4.36E+06
		Bq/m³ =	4.36E+06	
I-133				
0m – 0.3m	3.93E+07	3.94E+07	3.94E+07	3.94E+07
		Bq/m³ =	3.94E+07	

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Radionuclide and soil depth	Time (y)			
	1	40	60	80
Sb-124				
0m – 0.3m	2.10E+09	2.74E+09	2.74E+09	2.74E+09
		Bq/m³ =	2.74E+09	
Sr-89				
0m – 0.3m	1.84E+09	2.29E+09	2.29E+09	2.29E+09
		Bq/m³ =	2.29E+09	

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Appendix 7.3: NNPS Source Terms

A bounding NNPS source term is calculated for the site that represents 33 000 MW_{th} energy generated by GEN III technology NNPS. The source term is derived as follows:

The annual operational discharges, liquid and airborne, of four reference GEN III NNPS are selected. The NNPS are:

- (5) AP1000 – U.S.A. (Westinghouse, 2007)
- (6) EPR – France (AREVA, 2007)
- (7) AP1400 – Korea (KEPCO, 2018)
- (8) HPR1000 - China (GNS, 2020)

It is important to note that the different vendors report different sets of nuclides for normal operational discharges (also referred to as radionuclide vectors) and which do not necessarily overlap, i.e., different nuclide vectors per reactor type.

A reactor thermal power that equates to 33 000 MW_{th} is calculated for each of the NNPS reactor type as is shown in **Table A7.3.1**.

Table A7.3.1: Equivalent Reactor Thermal Power for Representative NNPS

Parameter	AP1000	EPR	APR1400	HPR1000
MWe per reactor unit	1117.00	1710.00	1400.00	1180.00
MW _{th} per reactor unit	3415.00	4500.00	3983.00	3500.00
Reactor units per 33000 MW _{th}	9.66	7.33	8.29	9.43

The annual radionuclide specific discharges for liquid and airborne are listed and converted to nuclide specific source term per unit reactor type generating a total of 33 000 MW_{th}. The results are listed in **Table A7.3.2** for liquid source terms per nuclide and **Table A7.3.3** for airborne source terms per nuclides. Empty spaces in the tables indicate no values reported for the specific NNPS in the reference documents.

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Table A7.3.2: Site Enveloping Source Term for Normal Continuous Discharges: Liquid

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Table A7.3.3: Site Enveloping Source Term for Normal Continuous Discharges: Airborne

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Appendix 7.4: Airborne and Liquid Site Dose Conversion Factors (DCF)

Table A.7.4.1: Individual doses (μSv per Bq/y) due to atmospheric discharges - Age: Adult, Time: 60 years – St. Francis

Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Cow milk products	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Ag-110m	3.57E-13	1.36E-14	4.18E-18	2.84E-12	4.00E-13	2.99E-16	2.31E-13	2.98E-14	3.97E-12	2.14E-11	2.35E-14	6.61E-14	1.07E-13	2.79E-14	8.44E-14	2.96E-11
Ar-41	0.00E+00	5.02E-15	4.16E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.06E-15
Ba-137m	0.00E+00	5.93E-19	1.13E-21	1.37E-21	2.06E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.96E-19
Ba-139	1.84E-15	1.61E-16	7.63E-17	5.28E-18	1.50E-16	1.98E-20	7.30E-24	3.77E-22	8.19E-19	4.41E-18	6.62E-19	5.93E-19	1.21E-17	3.33E-21	7.82E-22	2.25E-15
Ba-140	2.39E-13	9.18E-16	2.75E-17	1.32E-13	1.58E-14	1.02E-16	3.08E-17	1.59E-15	2.17E-14	1.17E-13	3.37E-15	1.76E-14	4.31E-14	4.29E-17	4.49E-15	5.97E-13
La-140	6.34E-16	1.33E-16	7.44E-19	1.85E-16	4.91E-17	1.11E-19	4.11E-20	5.30E-20	1.75E-18	9.43E-18	4.66E-18	9.82E-18	8.37E-17	1.70E-20	1.20E-19	1.11E-15
La-140	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.41E-17	3.75E-17	1.24E-15	5.88E-16	3.17E-15	2.50E-15	1.46E-14	2.97E-14	2.53E-17	3.49E-15	5.54E-14
Br-82	2.91E-14	1.30E-14	9.22E-18	1.57E-14	6.44E-16	5.15E-18	9.74E-19	4.02E-18	3.79E-14	2.04E-13	1.88E-16	2.41E-16	1.77E-15	8.11E-17	1.06E-17	3.03E-13
Br-83	1.83E-15	3.13E-17	2.67E-17	2.42E-18	1.30E-16	3.38E-20	7.95E-23	3.28E-22	4.56E-17	2.46E-16	4.75E-19	4.27E-19	8.63E-18	1.18E-20	7.10E-22	2.32E-15
Kr-83m	0.00E+00	5.32E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.32E-20
Kr-83m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	6.97E-16	3.40E-15	6.29E-17	7.15E-17	3.46E-17	3.04E-21	1.08E-24	4.47E-24	2.80E-18	1.51E-17	1.13E-19	1.01E-19	2.07E-18	2.29E-21	9.38E-24	4.28E-15
C-14	9.92E-14	0.00E+00	4.81E-19	0.00E+00	0.00E+00	0.00E+00	1.99E-15	1.03E-13	1.30E-13	3.82E-13	6.94E-14	3.83E-13	8.78E-14	2.16E-13	1.84E-13	1.66E-12
Ce-141	1.50E-13	4.13E-16	1.11E-17	6.34E-15	1.42E-14	8.20E-17	1.37E-16	3.53E-17	1.55E-15	8.35E-15	9.32E-16	8.44E-16	1.70E-14	4.78E-18	1.05E-16	2.00E-13
Co-57	2.58E-14	7.00E-16	1.75E-19	8.14E-14	5.45E-16	2.19E-17	1.68E-16	8.68E-17	5.90E-16	3.18E-15	1.10E-15	4.18E-15	7.27E-15	1.37E-16	2.44E-16	1.25E-13
Co-58	7.51E-14	4.88E-15	2.55E-18	2.79E-13	6.12E-15	4.88E-17	2.54E-16	1.31E-16	1.83E-15	9.89E-15	2.84E-15	1.22E-14	2.21E-14	1.52E-16	3.94E-16	4.15E-13
Co-60	4.69E-13	1.21E-14	4.59E-18	1.94E-11	2.49E-14	6.33E-16	4.91E-15	2.53E-15	1.17E-14	6.29E-14	2.17E-14	7.41E-14	1.28E-13	1.40E-14	6.77E-15	2.03E-11
Cr-51	1.73E-15	1.64E-16	0.00E+00	3.14E-15	6.33E-18	9.13E-19	9.28E-18	4.79E-16	8.01E-17	4.32E-16	4.73E-17	4.28E-17	8.66E-16	6.51E-20	1.47E-15	8.48E-15

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Cow milk products	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Cs-134	3.10E-13	7.80E-15	1.39E-17	4.62E-12	7.64E-14	3.26E-16	7.45E-14	3.84E-12	2.92E-12	1.58E-11	1.70E-12	2.93E-12	8.19E-13	1.81E-12	1.34E-11	4.83E-11
Cs-136	5.62E-14	1.08E-14	7.07E-18	1.15E-13	4.20E-15	2.42E-17	2.05E-15	1.06E-13	1.82E-13	9.83E-13	4.55E-14	8.31E-14	5.51E-14	4.48E-14	3.87E-13	2.07E-12
Cs-137	2.16E-13	0.00E+00	1.37E-17	1.67E-11	1.32E-13	5.42E-16	5.88E-14	3.03E-12	2.24E-12	1.21E-11	1.23E-12	2.15E-12	6.45E-13	1.40E-12	1.14E-11	5.14E-11
Ba-137m	0.00E+00	3.00E-15	7.65E-18	4.23E-18	6.37E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.01E-15
Cs-138	4.57E-16	4.70E-15	6.20E-17	9.74E-17	4.03E-17	2.02E-21	2.59E-25	1.33E-23	4.85E-22	2.61E-21	1.21E-19	1.08E-19	2.21E-18	7.55E-22	4.09E-20	5.36E-15
Fe-59	1.73E-13	5.78E-15	7.28E-18	2.23E-13	1.22E-14	1.02E-16	1.96E-14	2.53E-16	2.07E-15	1.12E-14	5.61E-15	2.58E-14	4.87E-14	8.05E-17	7.53E-16	5.28E-13
H-3	1.34E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.75E-18	3.48E-16	1.70E-15	3.66E-16	4.04E-16	6.20E-17	5.11E-16	1.26E-15	6.26E-16	6.62E-15
I-129	1.07E-12	2.67E-17	1.76E-19	3.81E-13	2.06E-15	3.34E-14	5.87E-13	3.03E-11	1.70E-10	9.16E-10	6.46E-11	1.07E-10	3.84E-11	9.00E-11	1.42E-10	1.56E-09
I-130	1.91E-14	6.75E-15	1.73E-17	2.26E-14	3.71E-15	1.38E-17	1.86E-17	9.58E-16	1.32E-14	7.13E-14	7.89E-16	7.79E-16	1.26E-14	9.74E-17	9.35E-16	1.53E-13
I-131	2.19E-13	1.27E-15	9.97E-18	6.13E-14	3.13E-14	6.84E-16	1.43E-14	7.39E-13	6.59E-12	3.55E-11	8.86E-13	1.57E-12	1.58E-12	8.12E-13	1.70E-12	4.97E-11
Xe-131m	0.00E+00	5.61E-20	9.95E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.60E-20
Xe-131m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-132	2.27E-15	6.04E-15	2.83E-17	3.87E-15	9.60E-16	3.36E-19	2.27E-20	1.17E-18	2.00E-17	1.08E-16	1.62E-17	1.46E-17	2.95E-16	3.98E-19	9.55E-19	1.36E-14
I-132m	1.67E-15	7.48E-16	0.00E+00	2.33E-15	7.20E-17	1.50E-19	2.97E-21	1.53E-19	2.74E-18	1.48E-17	6.53E-18	5.85E-18	1.19E-16	1.42E-19	1.24E-19	4.96E-15
I-132	4.34E-16	1.13E-15	5.42E-18	7.31E-16	1.82E-16	6.35E-20	4.30E-21	2.22E-19	3.78E-18	2.04E-17	3.07E-18	2.76E-18	5.58E-17	7.54E-20	1.81E-19	2.56E-15
I-132	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.78E-19	2.46E-20	1.27E-18	2.14E-17	1.15E-16	8.62E-18	7.79E-18	1.56E-16	2.50E-19	1.04E-18	3.12E-16
I-133	4.35E-14	1.95E-15	2.75E-17	1.11E-14	9.19E-15	4.64E-17	1.23E-16	6.33E-15	8.22E-14	4.43E-13	3.42E-15	3.76E-15	4.54E-14	8.42E-16	6.98E-15	6.58E-13
Xe-133	0.00E+00	6.05E-19	1.56E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.21E-19
Xe-133m	0.00E+00	1.06E-18	1.11E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-18
Xe-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-134	7.80E-16	5.03E-15	2.62E-17	1.24E-15	3.27E-16	4.42E-20	2.49E-22	1.29E-20	2.38E-19	1.28E-18	1.69E-18	1.51E-18	3.09E-17	3.50E-20	1.04E-20	7.44E-15

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Cow milk products	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
I-135	8.82E-15	4.61E-15	2.32E-17	1.03E-14	2.40E-15	3.68E-18	1.79E-18	9.21E-17	1.38E-15	7.43E-15	1.75E-16	1.62E-16	3.07E-15	9.53E-18	8.10E-17	3.85E-14
Xe-135	0.00E+00	5.08E-17	1.26E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.20E-17
Xe-135m	0.00E+00	1.26E-15	6.15E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-15
Xe-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-83m	0.00E+00	1.99E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E-19
Kr-85	0.00E+00	1.19E-17	2.60E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.79E-17
Kr-85m	0.00E+00	8.22E-16	2.38E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.46E-16
Kr-85	0.00E+00	5.82E-23	1.30E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.88E-22
Kr-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-87	0.00E+00	2.70E-15	1.19E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.82E-15
Rb-87	2.40E-29	0.00E+00	2.98E-33	0.00E+00	3.10E-29	8.35E-32	1.25E-29	6.45E-28	2.51E-27	1.35E-26	2.53E-28	3.85E-28	2.19E-28	5.27E-28	1.41E-27	1.95E-26
Rb-87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-88	0.00E+00	8.00E-15	3.46E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.03E-15
Rb-88	5.56E-16	2.14E-15	1.99E-16	2.38E-17	4.18E-17	1.23E-21	1.25E-24	6.44E-23	7.21E-19	3.89E-18	1.09E-19	1.01E-19	1.98E-18	1.08E-20	1.19E-22	2.97E-15
Rb-88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
La-140	5.10E-14	1.10E-14	5.98E-17	1.61E-14	4.28E-15	9.70E-18	3.57E-18	4.61E-18	1.52E-16	8.21E-16	4.06E-16	8.54E-16	7.28E-15	1.48E-18	1.04E-17	9.20E-14
Mn-54	7.04E-14	4.18E-15	0.00E+00	1.06E-12	9.94E-17	6.16E-17	2.67E-15	3.49E-15	5.75E-15	3.10E-14	5.20E-15	1.59E-14	2.64E-14	4.50E-15	1.07E-14	1.24E-12
Mo-99	4.15E-14	7.54E-16	4.23E-17	2.52E-15	5.18E-15	1.01E-17	2.72E-17	7.01E-17	3.80E-15	2.05E-14	1.97E-16	5.85E-16	3.38E-15	2.52E-18	1.65E-16	7.87E-14
Tc-99m	7.03E-17	5.49E-17	4.22E-20	6.20E-18	3.27E-19	2.94E-21	1.80E-20	2.32E-19	3.34E-19	1.80E-18	9.30E-20	1.73E-19	1.10E-18	2.66E-19	4.23E-19	1.36E-16
Tc-99	4.99E-23	0.00E+00	9.33E-28	0.00E+00	6.87E-24	1.71E-25	6.59E-22	8.50E-21	9.69E-22	5.22E-21	4.19E-22	7.73E-22	5.07E-22	9.96E-22	1.09E-20	2.90E-20
Tc-99m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.93E-19	5.92E-18	6.69E-17	9.28E-17	5.00E-16	1.56E-17	4.43E-17	1.42E-16	4.45E-17	1.36E-16	1.05E-15

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Cow milk products	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Na-24	1.23E-14	1.80E-14	6.13E-17	1.06E-14	1.66E-15	1.23E-18	1.34E-18	6.89E-17	2.59E-15	1.40E-14	4.07E-17	4.15E-17	6.17E-16	6.06E-18	2.47E-16	6.01E-14
Nb-95	7.03E-14	3.83E-15	4.91E-19	1.09E-13	3.81E-16	3.92E-17	4.74E-21	2.44E-19	5.17E-18	2.79E-17	1.60E-15	7.59E-15	1.47E-14	6.05E-17	7.43E-19	2.08E-13
Ni-63	2.25E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.25E-17	6.54E-18	3.37E-17	6.47E-15	3.49E-14	1.98E-15	4.52E-15	6.81E-15	3.40E-15	2.27E-17	8.07E-14
Rb-86	4.36E-14	4.64E-16	7.96E-17	7.36E-15	5.13E-14	2.07E-17	9.58E-16	4.94E-14	5.58E-13	3.01E-12	6.45E-14	1.19E-13	6.26E-14	6.66E-14	1.43E-13	4.18E-12
Rb-88	1.52E-16	6.31E-16	5.46E-17	7.69E-18	1.35E-17	3.97E-22	4.04E-25	2.08E-23	2.33E-19	1.26E-18	3.53E-20	3.25E-20	6.40E-19	3.49E-21	3.85E-23	8.61E-16
Ru-103	1.13E-13	2.40E-15	2.44E-18	7.15E-14	4.46E-15	6.43E-17	1.11E-17	5.71E-16	1.66E-17	8.96E-17	1.03E-15	9.38E-16	1.85E-14	5.94E-17	1.72E-15	2.14E-13
Rh-103m	5.16E-17	3.29E-19	0.00E+00	1.45E-21	0.00E+00	3.44E-22	2.24E-26	1.15E-24	1.43E-19	7.74E-19	7.55E-21	6.84E-21	1.38E-19	6.06E-23	3.27E-24	5.30E-17
Ru-106	1.31E-12	0.00E+00	0.00E+00	2.96E-13	4.44E-13	1.19E-15	5.55E-16	2.86E-14	2.02E-16	1.09E-15	1.44E-14	1.36E-14	2.33E-13	5.18E-15	7.51E-14	2.43E-12
Rh-106	0.00E+00	1.04E-15	1.78E-16	2.81E-19	1.51E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-15
Sb-122	4.66E-14	2.22E-15	6.51E-17	4.68E-15	7.02E-15	1.13E-17	6.90E-16	3.56E-16	1.05E-15	5.65E-15	5.39E-16	1.58E-15	9.41E-15	6.99E-18	8.39E-16	8.07E-14
Sb-124	3.00E-13	8.80E-15	4.12E-17	4.54E-13	7.34E-14	1.89E-16	2.36E-14	1.22E-14	6.07E-15	3.27E-14	9.06E-15	3.96E-14	7.26E-14	4.46E-16	4.03E-14	1.07E-12
Sb-125	2.25E-13	2.14E-15	5.26E-18	1.59E-12	2.87E-14	2.54E-16	1.75E-14	9.00E-15	3.52E-15	1.90E-14	6.95E-15	2.38E-14	4.03E-14	2.46E-15	3.36E-14	2.01E-12
Te-125m	5.71E-17	1.71E-20	4.88E-22	1.30E-19	1.79E-20	3.29E-20	1.33E-19	6.88E-18	3.46E-18	1.87E-17	1.56E-17	2.81E-17	9.59E-18	1.66E-17	2.28E-17	1.79E-16
Te-125m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.57E-17	3.38E-15	7.47E-15	2.91E-15	1.57E-14	1.22E-14	3.17E-14	7.43E-15	1.17E-14	4.09E-14	1.33E-13
Sr-89	2.86E-13	4.20E-19	6.85E-17	1.75E-17	1.13E-13	1.73E-16	5.14E-17	2.65E-15	4.95E-14	2.67E-13	8.79E-15	4.00E-14	7.47E-14	1.20E-15	6.76E-15	8.49E-13
Sr-90	1.69E-12	0.00E+00	1.74E-17	2.16E-19	5.60E-13	4.21E-15	4.16E-15	2.15E-13	3.80E-12	2.05E-11	4.40E-13	2.28E-12	4.39E-12	1.71E-12	2.89E-13	3.59E-11
Y-90	5.46E-16	2.45E-24	8.96E-19	5.97E-25	6.92E-17	1.21E-19	1.10E-21	5.68E-21	2.36E-18	1.27E-17	6.11E-18	1.78E-17	1.07E-16	7.91E-20	1.33E-20	7.62E-16
Sr-91	1.65E-14	3.29E-15	7.34E-17	1.87E-15	1.04E-15	1.13E-18	7.35E-21	3.79E-19	4.01E-17	2.16E-16	3.21E-17	3.43E-17	5.88E-16	1.34E-18	2.47E-18	2.37E-14
Y-91m	2.23E-16	1.14E-15	1.32E-18	2.95E-17	2.15E-18	1.32E-21	3.82E-27	1.97E-26	6.32E-22	3.41E-21	2.06E-20	1.84E-20	3.78E-19	2.07E-22	4.10E-26	1.40E-15
Y-91	1.44E-16	5.91E-21	2.46E-20	2.85E-19	4.10E-17	8.33E-20	3.65E-21	1.88E-20	3.71E-19	2.00E-18	2.75E-18	1.20E-17	2.21E-17	1.33E-19	5.48E-20	2.25E-16
Y-91m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.35E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.41E-19	5.64E-19	9.88E-18	5.69E-21	0.00E+00	1.10E-17

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Cow milk products	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Sr-92	8.21E-15	5.40E-15	1.45E-17	6.45E-16	7.28E-17	1.72E-19	4.43E-23	2.29E-21	4.41E-19	2.38E-18	5.46E-18	5.16E-18	1.00E-16	2.21E-19	6.44E-20	1.45E-14
Y-92	1.00E-15	1.43E-16	2.19E-17	1.70E-17	6.93E-17	2.51E-20	3.03E-24	1.56E-23	1.17E-19	6.32E-19	1.06E-18	9.69E-19	1.94E-17	1.08E-20	3.28E-23	1.27E-15
Y-92	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.16E-18	5.82E-18	1.13E-16	6.35E-20	0.00E+00	1.25E-16
Tc-99m	8.21E-16	6.56E-16	4.93E-19	7.86E-17	4.15E-18	3.73E-20	2.28E-19	2.95E-18	4.24E-18	2.28E-17	1.18E-18	2.19E-18	1.40E-17	3.38E-18	5.36E-18	1.62E-15
Tc-99	4.80E-23	0.00E+00	8.96E-28	0.00E+00	6.61E-24	1.64E-25	6.35E-22	8.18E-21	9.33E-22	5.03E-21	4.03E-22	7.44E-22	4.89E-22	9.59E-22	1.05E-20	2.80E-20
Tc-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.05E-24	8.01E-21	1.03E-19	1.18E-20	6.35E-20	5.09E-21	9.40E-21	6.17E-21	1.21E-20	1.33E-19	3.52E-19
Te-125m	1.60E-13	4.81E-17	1.36E-18	3.92E-16	5.41E-17	9.94E-17	4.03E-16	2.08E-14	1.05E-14	5.64E-14	4.72E-14	8.49E-14	2.90E-14	5.02E-14	6.88E-14	5.28E-13
Te-127	5.78E-15	2.38E-17	1.93E-17	6.75E-18	3.62E-16	3.93E-19	4.96E-20	2.56E-18	4.64E-17	2.50E-16	8.96E-18	8.48E-18	1.51E-16	5.93E-19	5.39E-18	6.67E-15
Te-129	1.14E-15	1.89E-16	3.91E-17	6.99E-18	8.35E-17	1.04E-20	4.09E-23	2.11E-21	3.03E-19	1.63E-18	2.76E-19	2.46E-19	5.04E-18	6.00E-22	4.34E-21	1.46E-15
I-129	3.99E-24	9.88E-29	6.59E-31	1.41E-24	7.60E-27	1.23E-25	2.17E-24	1.12E-22	6.27E-22	3.38E-21	2.38E-22	3.93E-22	1.42E-22	3.32E-22	5.25E-22	5.76E-21
I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.57E-26	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.92E-23	1.14E-22	4.10E-23	9.64E-23	0.00E+00	3.21E-22
Te-129m	3.09E-13	1.58E-16	2.58E-17	1.12E-14	1.01E-13	1.71E-16	1.09E-15	5.61E-14	3.31E-14	1.78E-13	1.17E-13	2.14E-13	8.53E-14	1.23E-13	1.78E-13	1.41E-12
Te-129	5.99E-16	9.61E-17	2.06E-17	3.33E-18	3.98E-17	4.94E-21	1.95E-23	1.00E-21	1.44E-19	7.77E-19	1.31E-19	1.17E-19	2.40E-18	2.86E-22	2.07E-21	7.62E-16
I-129	5.04E-24	1.25E-28	8.32E-31	1.77E-24	9.60E-27	1.55E-25	2.74E-24	1.41E-22	7.91E-22	4.26E-21	3.01E-22	4.96E-22	1.79E-22	4.19E-22	6.63E-22	7.26E-21
I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.12E-23	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E-22	1.68E-22	6.06E-23	1.42E-22	0.00E+00	5.04E-22
Te-131m	4.34E-14	6.94E-15	1.47E-17	8.85E-15	8.23E-16	6.97E-18	8.61E-18	4.44E-16	2.63E-15	1.42E-14	5.02E-16	6.10E-16	5.35E-15	1.80E-16	9.82E-16	8.49E-14
I-131	7.31E-16	4.09E-18	3.33E-20	2.02E-16	1.03E-16	2.25E-18	4.71E-17	2.43E-15	2.17E-14	1.17E-13	2.92E-15	5.17E-15	5.21E-15	2.67E-15	5.61E-15	1.64E-13
Te-131	8.89E-16	1.44E-15	5.64E-17	3.34E-17	3.46E-17	2.68E-21	2.63E-24	1.36E-22	5.41E-20	2.92E-19	1.30E-19	1.16E-19	2.39E-18	1.50E-22	2.79E-22	2.45E-15
I-131	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.91E-14	5.22E-14	4.25E-14	2.73E-14	0.00E+00	1.51E-13
Te-132	9.33E-14	1.15E-15	2.72E-18	3.23E-14	3.57E-16	2.45E-17	1.07E-16	5.52E-15	1.38E-14	7.46E-14	5.81E-15	9.06E-15	2.54E-14	4.08E-15	1.32E-14	2.79E-13
I-132	7.08E-16	1.80E-15	8.85E-18	1.19E-15	2.95E-16	1.03E-19	6.98E-21	3.60E-19	6.14E-18	3.31E-17	4.98E-18	4.48E-18	9.06E-17	1.22E-19	2.94E-19	4.14E-15

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Cow milk products	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
I-132	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-18	6.42E-21	3.31E-19	5.57E-18	3.01E-17	2.25E-18	2.03E-18	4.07E-17	6.52E-20	2.70E-19	8.24E-17
Te-133m	2.40E-15	6.83E-15	4.88E-17	2.81E-16	7.05E-17	1.76E-20	8.45E-23	4.36E-21	7.86E-19	4.24E-18	8.85E-19	7.87E-19	1.62E-17	1.54E-21	8.97E-21	9.66E-15
I-133	1.03E-15	4.44E-17	6.50E-19	2.59E-16	2.14E-16	1.08E-18	2.86E-18	1.48E-16	1.92E-15	1.03E-14	7.97E-17	8.77E-17	1.06E-15	1.96E-17	1.63E-16	1.53E-14
Te-133	5.84E-16	2.88E-15	6.16E-17	3.32E-17	1.82E-17	9.22E-22	2.64E-25	1.36E-23	1.09E-20	5.88E-20	5.18E-20	4.61E-20	9.49E-19	5.38E-23	2.79E-23	3.58E-15
I-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.81E-17	2.00E-17	2.37E-16	4.60E-18	0.00E+00	2.80E-16
Te-134	1.54E-15	2.28E-15	3.96E-18	2.16E-16	1.96E-17	8.65E-21	1.24E-23	6.42E-22	1.53E-19	8.26E-19	2.25E-19	2.00E-19	4.12E-18	3.21E-22	1.32E-21	4.07E-15
I-134	5.09E-16	3.13E-15	1.71E-17	7.95E-16	2.10E-16	2.84E-20	1.60E-22	8.25E-21	1.53E-19	8.23E-19	1.08E-18	9.71E-19	1.98E-17	2.24E-20	6.70E-21	4.68E-15
I-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.90E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E-19	2.02E-19	4.11E-18	4.88E-21	0.00E+00	4.55E-18
Xe-131m	0.00E+00	4.45E-17	7.84E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.23E-17
Xe-133	0.00E+00	2.14E-16	5.49E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.19E-16
Xe-133m	0.00E+00	1.57E-16	1.62E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.73E-16
Xe-133	0.00E+00	8.32E-19	2.17E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.54E-19
Xe-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135	0.00E+00	1.30E-15	3.19E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E-15
Cs-135	8.05E-25	0.00E+00	2.71E-29	0.00E+00	1.81E-25	2.78E-27	2.13E-25	1.10E-23	8.13E-24	4.38E-23	4.45E-24	7.91E-24	2.52E-24	5.35E-24	4.19E-23	1.26E-22
Cs-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135m	0.00E+00	3.82E-16	1.77E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.83E-16
Xe-135	0.00E+00	3.10E-17	7.68E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.18E-17
Xe-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-137	0.00E+00	2.18E-18	4.11E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-18
Xe-138	0.00E+00	8.30E-16	1.05E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.40E-16

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Cow milk products	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Cs-138	2.44E-16	2.45E-15	3.31E-17	4.94E-17	2.04E-17	1.02E-21	1.31E-25	6.76E-24	2.46E-22	1.32E-21	6.11E-20	5.45E-20	1.12E-18	3.82E-22	2.07E-20	2.80E-15
Cs-138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Zr-95	2.25E-13	3.70E-15	6.98E-18	3.90E-13	1.53E-14	1.43E-16	1.05E-20	5.41E-19	1.38E-17	7.43E-17	3.49E-15	1.52E-14	2.79E-14	5.78E-17	1.85E-18	6.81E-13
Nb-95	4.16E-17	2.21E-18	2.90E-22	5.97E-17	2.08E-19	2.14E-20	2.59E-24	1.33E-22	2.83E-21	1.52E-20	8.73E-19	4.15E-18	8.03E-18	3.30E-20	4.06E-22	1.17E-16
Nb-95m	2.13E-16	1.82E-18	9.16E-20	6.34E-17	1.14E-17	5.40E-20	1.15E-24	5.91E-23	9.39E-21	5.06E-20	1.24E-18	4.37E-18	2.10E-17	1.71E-20	1.43E-22	3.16E-16
Nb-95	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.24E-17	5.79E-21	2.99E-19	1.12E-18	6.04E-18	1.24E-15	3.86E-15	5.17E-15	1.08E-16	1.03E-18	1.04E-14
Total	8.73E-12	2.31E-13	2.15E-15	4.90E-11	2.15E-12	4.32E-14	1.05E-12	3.86E-11	1.91E-10	1.03E-09	6.93E-11	1.17E-10	4.72E-11	9.63E-11	1.71E-10	1.82E-09

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Table A.7.4.2: Individual doses (μSv per Bq/y) due to atmospheric discharges - Age: Child, Time: 60 years – St. Francis

Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Ag-110m	3.89E-13	3.81E-15	4.18E-18	5.39E-13	4.00E-13	3.26E-16	6.14E-14	1.55E-14	7.22E-12	1.31E-14	3.55E-14	8.32E-14	1.71E-14	2.03E-14	8.80E-12
Ar-41	0.00E+00	1.40E-15	4.16E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.45E-15
Ba-137m	0.00E+00	1.66E-19	1.13E-21	2.60E-22	2.06E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E-19
Ba-139	2.27E-15	4.50E-17	7.63E-17	1.00E-18	1.50E-16	2.45E-20	2.09E-24	2.11E-22	1.60E-18	3.97E-19	3.43E-19	1.01E-17	2.20E-21	2.03E-22	2.56E-15
Ba-140	2.46E-13	2.57E-16	2.75E-17	2.51E-14	1.58E-14	1.05E-16	9.82E-18	9.91E-16	4.74E-14	2.25E-15	1.14E-14	4.02E-14	3.16E-17	1.30E-15	3.91E-13
La-140	7.97E-16	3.73E-17	7.44E-19	3.52E-17	4.91E-17	1.40E-19	1.23E-20	3.11E-20	3.60E-18	2.93E-18	5.96E-18	7.35E-17	1.18E-20	3.26E-20	1.01E-15
La-140	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.77E-17	1.12E-17	7.27E-16	1.21E-15	1.58E-15	8.87E-15	2.61E-14	1.76E-17	9.47E-16	3.95E-14
Br-82	3.52E-14	3.63E-15	9.22E-18	2.99E-15	6.44E-16	6.22E-18	2.45E-19	1.98E-18	6.52E-14	9.94E-17	1.22E-16	1.30E-15	4.72E-17	2.41E-18	1.09E-13
Br-83	2.03E-15	8.77E-18	2.67E-17	4.60E-19	1.30E-16	3.75E-20	2.19E-23	1.77E-22	8.62E-17	2.75E-19	2.38E-19	6.97E-18	7.56E-21	1.77E-22	2.29E-15
Kr-83m	0.00E+00	1.49E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-20
Kr-83m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	8.99E-16	9.51E-16	6.29E-17	1.36E-17	3.46E-17	3.92E-21	2.81E-25	2.27E-24	4.98E-18	6.16E-20	5.31E-20	1.57E-18	1.37E-21	2.21E-24	1.97E-15
C-14	9.60E-14	0.00E+00	4.81E-19	0.00E+00	0.00E+00	0.00E+00	3.92E-16	3.96E-14	1.75E-13	2.87E-14	1.53E-13	5.06E-14	9.84E-14	3.29E-14	6.75E-13
Ce-141	1.49E-13	1.16E-16	1.11E-17	1.21E-15	1.42E-14	8.16E-17	4.13E-17	2.09E-17	3.20E-15	5.90E-16	5.15E-16	1.50E-14	3.34E-18	2.87E-17	1.84E-13
Co-57	2.76E-14	1.96E-16	1.75E-19	1.55E-14	5.45E-16	2.34E-17	6.64E-17	6.70E-17	1.60E-15	9.12E-16	3.33E-15	8.40E-15	1.25E-16	8.74E-17	5.84E-14
Co-58	7.78E-14	1.37E-15	2.55E-18	5.30E-14	6.12E-15	5.06E-17	8.32E-17	8.41E-17	4.12E-15	1.96E-15	8.09E-15	2.13E-14	1.16E-16	1.17E-16	1.74E-13
Co-60	4.87E-13	3.39E-15	4.59E-18	3.69E-12	2.49E-14	6.57E-16	2.27E-15	2.29E-15	3.69E-14	2.10E-14	6.93E-14	1.73E-13	1.50E-14	2.83E-15	4.53E-12
Cr-51	2.14E-15	4.59E-17	0.00E+00	5.97E-16	6.33E-18	1.13E-18	2.72E-18	2.75E-16	1.61E-16	2.91E-17	2.54E-17	7.43E-16	4.42E-20	3.91E-16	4.42E-15
Cs-134	1.72E-13	2.18E-15	1.39E-17	8.77E-13	7.64E-14	1.81E-16	7.85E-15	7.92E-13	2.11E-12	3.75E-13	6.24E-13	2.52E-13	4.42E-13	1.28E-12	7.01E-12
Cs-136	6.48E-14	3.02E-15	7.07E-18	2.18E-14	4.20E-15	2.79E-17	4.30E-16	4.34E-14	2.62E-13	2.00E-14	3.52E-14	3.38E-14	2.17E-14	7.34E-14	5.83E-13

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Cs-137	1.20E-13	0.00E+00	1.37E-17	3.18E-12	1.32E-13	3.02E-16	6.46E-15	6.53E-13	1.69E-12	2.83E-13	4.79E-13	2.07E-13	3.57E-13	1.13E-12	8.24E-12
Ba-137m	0.00E+00	8.40E-16	7.65E-18	8.03E-19	6.37E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.49E-16
Cs-138	6.59E-16	1.32E-15	6.20E-17	1.85E-17	4.03E-17	2.90E-21	6.83E-26	6.89E-24	8.77E-22	6.68E-20	5.75E-20	1.71E-18	4.61E-22	9.77E-21	2.10E-15
Fe-59	1.78E-13	1.62E-15	7.28E-18	4.23E-14	1.22E-14	1.05E-16	7.33E-15	1.85E-16	5.30E-15	4.39E-15	1.95E-14	5.31E-14	6.95E-17	2.55E-16	3.25E-13
H-3	1.18E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.23E-18	1.24E-16	2.12E-15	1.55E-16	2.29E-17	2.73E-16	5.31E-16	1.04E-16	4.52E-15
I-129	1.37E-12	7.48E-18	1.76E-19	7.24E-14	2.06E-15	4.29E-14	1.45E-13	1.46E-11	2.87E-10	3.34E-11	5.32E-11	2.77E-11	5.14E-11	3.18E-11	5.01E-10
I-130	3.16E-14	1.89E-15	1.73E-17	4.30E-15	3.71E-15	2.28E-17	6.10E-18	6.16E-16	2.98E-14	5.44E-16	5.17E-16	1.21E-14	7.41E-17	2.78E-16	8.54E-14
I-131	3.89E-13	3.56E-16	9.97E-18	1.16E-14	3.13E-14	1.22E-15	4.84E-15	4.88E-13	1.52E-11	6.28E-13	1.07E-12	1.56E-12	6.35E-13	5.21E-13	2.06E-11
Xe-131m	0.00E+00	1.57E-20	9.95E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-20
Xe-131m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-132	3.67E-15	1.69E-15	2.83E-17	7.34E-16	9.60E-16	5.43E-19	6.94E-21	7.01E-19	4.18E-17	1.04E-17	9.00E-18	2.63E-16	2.82E-19	2.64E-19	7.41E-15
I-132m	2.77E-15	2.09E-16	0.00E+00	4.42E-16	7.20E-17	2.49E-19	9.63E-22	9.73E-20	6.09E-18	4.44E-18	3.84E-18	1.13E-16	1.06E-19	3.65E-20	3.62E-15
I-132	7.02E-16	3.15E-16	5.42E-18	1.39E-16	1.82E-16	1.03E-19	1.31E-21	1.33E-19	7.91E-18	1.96E-18	1.70E-18	4.98E-17	5.33E-20	5.00E-20	1.40E-15
I-132	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-19	7.52E-21	7.59E-19	4.47E-17	5.53E-18	4.81E-18	1.39E-16	1.77E-19	2.87E-19	1.96E-16
I-133	7.61E-14	5.47E-16	2.75E-17	2.11E-15	9.19E-15	8.13E-17	4.08E-17	4.12E-15	1.87E-13	2.38E-15	2.53E-15	4.41E-14	6.48E-16	2.10E-15	3.31E-13
Xe-133	0.00E+00	1.69E-19	1.56E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-19
Xe-133m	0.00E+00	2.98E-19	1.11E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.09E-19
Xe-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-134	1.16E-15	1.41E-15	2.62E-17	2.35E-16	3.27E-16	6.59E-20	6.80E-23	6.87E-21	4.45E-19	9.67E-19	8.35E-19	2.47E-17	2.21E-20	2.58E-21	3.19E-15
I-135	1.51E-14	1.29E-15	2.32E-17	1.95E-15	2.40E-15	6.28E-18	6.04E-19	6.10E-17	3.19E-15	1.24E-16	1.11E-16	3.04E-15	7.45E-18	2.48E-17	2.73E-14
Xe-135	0.00E+00	1.42E-17	1.26E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-17

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Xe-135m	0.00E+00	3.53E-16	6.15E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.59E-16
Xe-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-83m	0.00E+00	5.57E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.57E-20
Kr-85	0.00E+00	3.33E-18	2.60E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.93E-17
Kr-85m	0.00E+00	2.30E-16	2.38E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.54E-16
Kr-85	0.00E+00	1.63E-23	1.30E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.47E-22
Kr-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-87	0.00E+00	7.55E-16	1.19E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.74E-16
Rb-87	3.65E-29	0.00E+00	2.98E-33	0.00E+00	3.10E-29	1.27E-31	3.69E-30	3.73E-28	5.07E-27	1.57E-28	2.30E-28	1.89E-28	3.60E-28	3.77E-28	6.83E-27
Rb-87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-88	0.00E+00	2.24E-15	3.46E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.27E-15
Rb-88	7.69E-16	6.00E-16	1.99E-16	4.52E-18	4.18E-17	1.70E-21	3.37E-25	3.40E-23	1.33E-18	6.19E-20	5.49E-20	1.56E-18	6.74E-21	2.91E-23	1.62E-15
Rb-88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
La-140	6.41E-14	3.08E-15	5.98E-17	3.06E-15	4.28E-15	1.22E-17	1.07E-18	2.71E-18	3.13E-16	2.55E-16	5.18E-16	6.39E-15	1.03E-18	2.83E-18	8.21E-14
Mn-54	7.79E-14	1.17E-15	0.00E+00	2.02E-13	9.94E-17	6.81E-17	7.00E-16	1.79E-15	1.03E-14	2.85E-15	8.43E-15	2.02E-14	2.73E-15	2.54E-15	3.30E-13
Mo-99	4.83E-14	2.11E-16	4.23E-17	4.78E-16	5.18E-15	1.18E-17	7.12E-18	3.59E-17	6.82E-15	1.09E-16	3.10E-16	2.59E-15	1.53E-18	3.91E-17	6.41E-14
Tc-99m	8.70E-17	1.54E-17	4.22E-20	1.18E-18	3.27E-19	3.64E-21	5.03E-21	1.27E-19	6.39E-19	5.45E-20	9.78E-20	9.01E-19	1.72E-19	1.07E-19	1.06E-16
Tc-99	4.92E-23	0.00E+00	9.33E-28	0.00E+00	6.87E-24	1.68E-25	1.91E-22	4.83E-21	1.93E-21	2.55E-22	4.54E-22	4.31E-22	6.69E-22	2.87E-21	1.17E-20
Tc-99m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.39E-19	1.65E-18	3.66E-17	1.78E-16	9.17E-18	2.50E-17	1.16E-16	2.88E-17	3.44E-17	4.30E-16
Na-24	1.79E-14	5.04E-15	6.13E-17	2.01E-15	1.66E-15	1.79E-18	3.42E-19	3.45E-17	4.54E-15	2.18E-17	2.15E-17	4.62E-16	3.59E-18	5.72E-17	3.18E-14
Nb-95	7.13E-14	1.07E-15	4.91E-19	2.08E-14	3.81E-16	3.97E-17	1.28E-21	1.30E-19	9.60E-18	9.09E-16	4.16E-15	1.17E-14	3.79E-17	1.82E-19	1.10E-13

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Ni-63	2.27E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.31E-17	1.74E-18	1.76E-17	1.18E-14	1.11E-15	2.44E-15	5.32E-15	2.10E-15	5.49E-18	4.56E-14
Rb-86	6.48E-14	1.30E-16	7.96E-17	1.40E-15	5.13E-14	3.08E-17	2.88E-16	2.91E-14	1.15E-12	4.08E-14	7.23E-14	5.51E-14	4.64E-14	3.91E-14	1.55E-12
Rb-88	2.10E-16	1.77E-16	5.46E-17	1.46E-18	1.35E-17	5.49E-22	1.09E-25	1.10E-23	4.31E-19	2.00E-20	1.78E-20	5.06E-19	2.18E-21	9.42E-24	4.58E-16
Ru-103	1.13E-13	6.71E-16	2.44E-18	1.36E-14	4.46E-15	6.49E-17	3.25E-18	3.28E-16	3.34E-17	6.33E-16	5.57E-16	1.59E-14	4.03E-17	4.57E-16	1.50E-13
Rh-103m	5.68E-17	9.22E-20	0.00E+00	2.75E-22	0.00E+00	3.79E-22	6.23E-27	6.29E-25	2.74E-19	4.41E-21	3.85E-21	1.13E-19	3.91E-23	8.25E-25	5.73E-17
Ru-106	1.33E-12	0.00E+00	0.00E+00	5.62E-14	4.44E-13	1.20E-15	1.70E-16	1.72E-14	4.24E-16	9.24E-15	8.40E-15	2.09E-13	3.67E-15	2.08E-14	2.10E-12
Rh-106	0.00E+00	2.90E-16	1.78E-16	5.34E-20	1.51E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.70E-16
Sb-122	5.79E-14	6.21E-16	6.51E-17	8.89E-16	7.02E-15	1.40E-17	2.15E-16	2.17E-16	2.23E-15	3.51E-16	9.95E-16	8.56E-15	5.03E-18	2.36E-16	7.94E-14
Sb-124	3.11E-13	2.46E-15	4.12E-17	8.62E-14	7.34E-14	1.96E-16	7.02E-15	7.09E-15	1.24E-14	5.65E-15	2.38E-14	6.31E-14	3.07E-16	1.09E-14	6.04E-13
Sb-125	2.21E-13	6.00E-16	5.26E-18	3.03E-13	2.87E-14	2.49E-16	4.76E-15	4.80E-15	6.57E-15	3.98E-15	1.31E-14	3.22E-14	1.55E-15	8.30E-15	6.28E-13
Te-125m	5.57E-17	4.79E-21	4.88E-22	2.46E-20	1.79E-20	3.21E-20	4.16E-20	4.20E-18	7.40E-18	1.02E-17	1.77E-17	8.75E-18	1.20E-17	6.44E-18	1.23E-16
Te-125m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.36E-17	1.06E-15	4.56E-15	6.22E-15	7.98E-15	2.00E-14	6.78E-15	8.46E-15	1.16E-14	6.67E-14
Sr-89	2.95E-13	1.18E-19	6.85E-17	3.33E-18	1.13E-13	1.78E-16	1.64E-17	1.65E-15	1.08E-13	5.88E-15	2.58E-14	6.97E-14	8.84E-16	1.95E-15	6.22E-13
Sr-90	1.65E-12	0.00E+00	1.74E-17	4.10E-20	5.60E-13	4.12E-15	1.28E-15	1.29E-13	7.98E-12	2.82E-13	1.41E-12	3.93E-12	1.21E-12	8.02E-14	1.72E-11
Y-90	6.79E-16	6.85E-25	8.96E-19	1.13E-25	6.92E-17	1.51E-19	3.44E-22	3.47E-21	5.05E-18	4.00E-18	1.12E-17	9.75E-17	5.71E-20	3.77E-21	8.67E-16
Sr-91	2.12E-14	9.22E-16	7.34E-17	3.56E-16	1.04E-15	1.46E-18	1.94E-21	1.96E-19	7.24E-17	1.77E-17	1.83E-17	4.54E-16	8.18E-19	5.91E-19	2.42E-14
Y-91m	2.80E-16	3.19E-16	1.32E-18	5.61E-18	2.15E-18	1.66E-21	1.04E-27	1.05E-26	1.18E-21	1.18E-20	1.02E-20	3.01E-19	1.31E-22	1.01E-26	6.09E-16
Y-91	1.46E-16	1.65E-21	2.46E-20	5.42E-20	4.10E-17	8.41E-20	1.13E-21	1.14E-20	7.87E-19	1.78E-18	7.54E-18	2.01E-17	9.54E-20	1.54E-20	2.17E-16
Y-91m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.22E-20	0.00E+00	0.00E+00	0.00E+00	3.09E-19	3.11E-19	7.88E-18	3.59E-21	0.00E+00	8.55E-18
Sr-92	1.11E-14	1.51E-15	1.45E-17	1.22E-16	7.28E-17	2.32E-19	1.21E-23	1.22E-21	8.23E-19	3.12E-18	2.85E-18	8.00E-17	1.39E-19	1.59E-20	1.29E-14
Y-92	1.34E-15	4.00E-17	2.19E-17	3.23E-18	6.93E-17	3.37E-20	8.83E-25	8.92E-24	2.34E-19	6.48E-19	5.71E-19	1.65E-17	7.27E-21	8.66E-24	1.50E-15

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Y-92	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.97E-19	0.00E+00	0.00E+00	0.00E+00	3.77E-18	3.43E-18	9.61E-17	4.28E-20	0.00E+00	1.04E-16
Tc-99m	1.02E-15	1.84E-16	4.93E-19	1.49E-17	4.15E-18	4.62E-20	6.38E-20	1.61E-18	8.10E-18	6.91E-19	1.24E-18	1.14E-17	2.18E-18	1.36E-18	1.25E-15
Tc-99	4.73E-23	0.00E+00	8.96E-28	0.00E+00	6.61E-24	1.62E-25	1.84E-22	4.65E-21	1.86E-21	2.45E-22	4.37E-22	4.15E-22	6.44E-22	2.77E-21	1.13E-20
Tc-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.02E-24	2.33E-21	5.87E-20	2.34E-20	3.10E-21	5.51E-21	5.24E-21	8.14E-21	3.49E-20	1.41E-19
Te-125m	1.56E-13	1.35E-17	1.36E-18	7.45E-17	5.41E-17	9.70E-17	1.26E-16	1.27E-14	2.24E-14	3.09E-14	5.36E-14	2.65E-14	3.63E-14	1.94E-14	3.58E-13
Te-127	7.38E-15	6.67E-18	1.93E-17	1.28E-18	3.62E-16	5.01E-19	1.50E-20	1.51E-18	9.61E-17	5.69E-18	5.19E-18	1.34E-16	4.16E-19	1.48E-18	8.02E-15
Te-129	1.38E-15	5.28E-17	3.91E-17	1.33E-18	8.35E-17	1.26E-20	1.11E-23	1.12E-21	5.64E-19	1.57E-19	1.35E-19	4.02E-18	3.78E-22	1.07E-21	1.56E-15
I-129	5.14E-24	2.77E-29	6.59E-31	2.67E-25	7.60E-27	1.59E-25	5.35E-25	5.40E-23	1.06E-21	1.23E-22	1.96E-22	1.02E-22	1.90E-22	1.18E-22	1.85E-21
I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.59E-26	0.00E+00	0.00E+00	0.00E+00	3.58E-23	5.69E-23	2.96E-23	5.51E-23	0.00E+00	1.77E-22
Te-129m	3.18E-13	4.44E-17	2.58E-17	2.13E-15	1.01E-13	1.75E-16	3.42E-16	3.45E-14	7.12E-14	7.71E-14	1.36E-13	7.84E-14	8.96E-14	5.06E-14	9.59E-13
Te-129	7.27E-16	2.69E-17	2.06E-17	6.32E-19	3.98E-17	6.00E-21	5.30E-24	5.35E-22	2.69E-19	7.49E-20	6.43E-20	1.91E-18	1.80E-22	5.09E-22	8.18E-16
I-129	6.49E-24	3.49E-29	8.32E-31	3.37E-25	9.60E-27	2.00E-25	6.75E-25	6.81E-23	1.34E-21	1.56E-22	2.48E-22	1.29E-22	2.39E-22	1.48E-22	2.33E-21
I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.02E-23	0.00E+00	0.00E+00	0.00E+00	5.28E-23	8.40E-23	4.37E-23	8.12E-23	0.00E+00	3.02E-22
Te-131m	6.06E-14	1.94E-15	1.47E-17	1.68E-15	8.23E-16	9.74E-18	2.78E-18	2.81E-16	5.83E-15	3.40E-16	3.99E-16	5.06E-15	1.34E-16	2.88E-16	7.74E-14
I-131	1.30E-15	1.15E-18	3.33E-20	3.83E-17	1.03E-16	4.00E-18	1.59E-17	1.61E-15	5.02E-14	2.07E-15	3.53E-15	5.15E-15	2.09E-15	1.72E-15	6.78E-14
Te-131	1.14E-15	4.02E-16	5.64E-17	6.34E-18	3.46E-17	3.45E-21	8.21E-25	8.29E-23	1.16E-19	8.53E-20	7.31E-20	2.18E-18	1.09E-22	7.88E-23	1.64E-15
I-131	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.35E-17	0.00E+00	0.00E+00	0.00E+00	2.06E-14	3.56E-14	4.20E-14	2.13E-14	0.00E+00	1.20E-13
Te-132	1.29E-13	3.23E-16	2.72E-18	6.13E-15	3.57E-16	3.39E-17	3.34E-17	3.37E-15	2.96E-14	3.81E-15	5.72E-15	2.32E-14	2.95E-15	3.74E-15	2.08E-13
I-132	1.15E-15	5.05E-16	8.85E-18	2.26E-16	2.95E-16	1.67E-19	2.13E-21	2.15E-19	1.29E-17	3.19E-18	2.77E-18	8.10E-17	8.66E-20	8.12E-20	2.28E-15
I-132	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.79E-18	1.96E-21	1.98E-19	1.17E-17	1.44E-18	1.25E-18	3.64E-17	4.61E-20	7.48E-20	5.28E-17
Te-133m	3.25E-15	1.91E-15	4.88E-17	5.34E-17	7.05E-17	2.38E-20	2.72E-23	2.74E-21	1.73E-18	5.97E-19	5.12E-19	1.52E-17	1.15E-21	2.61E-21	5.35E-15

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
I-133	1.80E-15	1.24E-17	6.50E-19	4.93E-17	2.14E-16	1.90E-18	9.50E-19	9.60E-17	4.36E-15	5.56E-17	5.89E-17	1.03E-15	1.51E-17	4.90E-17	7.74E-15
Te-133	7.67E-16	8.08E-16	6.16E-17	6.30E-18	1.82E-17	1.21E-21	8.38E-26	8.46E-24	2.37E-20	3.45E-20	2.96E-20	8.82E-19	3.95E-23	8.03E-24	1.66E-15
I-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.20E-19	0.00E+00	0.00E+00	0.00E+00	1.26E-17	1.35E-17	2.30E-16	3.53E-18	0.00E+00	2.60E-16
Te-134	1.94E-15	6.39E-16	3.96E-18	4.11E-17	1.96E-17	1.09E-20	3.56E-24	3.59E-22	3.00E-19	1.35E-19	1.16E-19	3.44E-18	2.12E-22	3.41E-22	2.64E-15
I-134	7.58E-16	8.76E-16	1.71E-17	1.51E-16	2.10E-16	4.23E-20	4.36E-23	4.40E-21	2.85E-19	6.20E-19	5.36E-19	1.58E-17	1.42E-20	1.65E-21	2.03E-15
I-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.79E-21	0.00E+00	0.00E+00	0.00E+00	1.29E-19	1.11E-19	3.28E-18	3.08E-21	0.00E+00	3.53E-18
Xe-131m	0.00E+00	1.24E-17	7.84E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.03E-17
Xe-133	0.00E+00	5.99E-17	5.49E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.53E-17
Xe-133m	0.00E+00	4.38E-17	1.62E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-17
Xe-133	0.00E+00	2.33E-19	2.17E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.55E-19
Xe-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135	0.00E+00	3.65E-16	3.19E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.97E-16
Cs-135	4.92E-25	0.00E+00	2.71E-29	0.00E+00	1.81E-25	1.70E-27	2.59E-26	2.62E-24	6.76E-24	1.13E-24	1.94E-24	8.97E-25	1.50E-24	4.61E-24	2.02E-23
Cs-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135m	0.00E+00	1.07E-16	1.77E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-16
Xe-135	0.00E+00	8.68E-18	7.68E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.45E-18
Xe-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-137	0.00E+00	6.12E-19	4.11E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E-18
Xe-138	0.00E+00	2.32E-16	1.05E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-16
Cs-138	3.51E-16	6.86E-16	3.31E-17	9.38E-18	2.04E-17	1.47E-21	3.46E-26	3.49E-24	4.45E-22	3.38E-20	2.91E-20	8.64E-19	2.34E-22	4.95E-21	1.10E-15
Cs-138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow liver	Cow meat	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Zr-95	2.20E-13	1.04E-15	6.98E-18	7.41E-14	1.53E-14	1.40E-16	3.00E-21	3.03E-19	2.70E-17	2.09E-15	8.81E-15	2.33E-14	3.82E-17	4.79E-19	3.45E-13
Nb-95	4.21E-17	6.18E-19	2.90E-22	1.13E-17	2.08E-19	2.17E-20	7.01E-25	7.08E-23	5.24E-21	4.96E-19	2.27E-18	6.37E-18	2.07E-20	9.96E-23	6.35E-17
Nb-95m	2.23E-16	5.10E-19	9.16E-20	1.20E-17	1.14E-17	5.67E-20	3.51E-25	3.54E-23	1.97E-20	7.94E-19	2.70E-18	1.88E-17	1.22E-20	3.97E-23	2.70E-16
Nb-95	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.26E-17	1.57E-21	1.58E-19	2.08E-18	7.03E-16	2.11E-15	4.10E-15	6.78E-17	2.53E-19	7.00E-15
Total	9.24E-12	6.48E-14	2.15E-15	9.32E-12	2.15E-12	5.30E-14	2.52E-13	1.69E-11	3.24E-10	3.53E-11	5.75E-11	3.50E-11	5.44E-11	3.52E-11	5.79E-10

Table A.7.4.3: Individual doses (μ Sv per Bq/y) due to atmospheric discharges - Age: Infant, Time: 60 years – St. Francis

Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Ag-110m	3.08E-13	3.81E-15	4.18E-18	5.39E-13	4.00E-13	2.58E-16	2.74E-12	9.30E-15	1.98E-14	6.81E-14	6.11E-16	2.05E-13	4.30E-12
Ar-41	0.00E+00	1.40E-15	4.16E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.45E-15
Ba-137m	0.00E+00	1.66E-19	1.13E-21	2.60E-22	2.06E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E-19
Ba-139	2.69E-15	4.50E-17	7.63E-17	1.00E-18	1.50E-16	2.91E-20	7.91E-19	3.66E-19	2.49E-19	1.08E-17	1.02E-22	2.66E-21	2.98E-15
Ba-140	2.20E-13	2.57E-16	2.75E-17	2.51E-14	1.58E-14	9.40E-17	2.07E-14	1.84E-15	7.33E-15	3.80E-14	1.30E-18	1.51E-14	3.44E-13
La-140	8.52E-16	3.73E-17	7.44E-19	3.52E-17	4.91E-17	1.50E-19	1.57E-18	2.39E-18	3.83E-18	6.91E-17	4.85E-22	3.78E-19	1.05E-15
La-140	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.89E-17	5.28E-16	1.29E-15	5.70E-15	2.46E-14	7.21E-19	1.10E-14	4.31E-14
Br-82	3.25E-14	3.63E-15	9.22E-18	2.99E-15	6.44E-16	5.75E-18	2.52E-14	7.17E-17	6.95E-17	1.09E-15	1.71E-18	2.47E-17	6.63E-14
Br-83	2.06E-15	8.77E-18	2.67E-17	4.60E-19	1.30E-16	3.80E-20	4.39E-17	2.62E-19	1.79E-19	7.66E-18	3.62E-22	2.40E-21	2.28E-15

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Kr-83m	0.00E+00	1.49E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-20
Kr-83m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	1.06E-15	9.51E-16	6.29E-17	1.36E-17	3.46E-17	4.62E-21	2.55E-18	5.89E-20	4.00E-20	1.73E-18	6.61E-23	3.00E-23	2.13E-15
C-14	7.68E-14	0.00E+00	4.81E-19	0.00E+00	0.00E+00	0.00E+00	4.94E-14	1.51E-14	6.35E-14	3.08E-14	2.61E-15	2.47E-13	4.85E-13
Ce-141	1.21E-13	1.16E-16	1.11E-17	1.21E-15	1.42E-14	6.62E-17	1.54E-15	5.29E-16	3.64E-16	1.56E-14	1.51E-19	3.66E-16	1.55E-13
Co-57	2.42E-14	1.96E-16	1.75E-19	1.55E-14	5.45E-16	2.06E-17	6.21E-16	6.64E-16	1.91E-15	7.05E-15	4.57E-18	9.04E-16	5.16E-14
Co-58	7.15E-14	1.37E-15	2.55E-18	5.30E-14	6.12E-15	4.65E-17	1.51E-15	1.34E-15	4.35E-15	1.68E-14	3.97E-18	1.14E-15	1.57E-13
Co-60	3.74E-13	3.39E-15	4.59E-18	3.69E-12	2.49E-14	5.05E-16	1.28E-14	1.36E-14	3.53E-14	1.29E-13	4.87E-16	2.61E-14	4.31E-12
Cr-51	2.31E-15	4.59E-17	0.00E+00	5.97E-16	6.33E-18	1.22E-18	6.70E-17	2.26E-17	1.56E-17	6.66E-16	1.73E-21	4.33E-15	8.06E-15
Cs-134	8.04E-14	2.18E-15	1.39E-17	8.77E-13	7.64E-14	8.46E-17	3.40E-13	1.13E-13	1.48E-13	8.77E-14	6.70E-15	5.49E-12	7.22E-12
Cs-136	5.71E-14	3.02E-15	7.07E-18	2.18E-14	4.20E-15	2.46E-17	7.97E-14	1.14E-14	1.58E-14	2.22E-14	6.22E-16	5.94E-13	8.10E-13
Cs-137	5.94E-14	0.00E+00	1.37E-17	3.18E-12	1.32E-13	1.49E-16	2.86E-13	8.97E-14	1.19E-13	7.57E-14	5.68E-15	5.11E-12	9.06E-12
Ba-137m	0.00E+00	8.40E-16	7.65E-18	8.03E-19	6.37E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.49E-16
Cs-138	8.05E-16	1.32E-15	6.20E-17	1.85E-17	4.03E-17	3.55E-21	4.30E-22	6.11E-20	4.14E-20	1.80E-18	2.12E-23	1.27E-19	2.24E-15
Fe-59	1.43E-13	1.62E-15	7.28E-18	4.23E-14	1.22E-14	8.41E-17	2.07E-15	3.20E-15	1.12E-14	4.47E-14	2.55E-18	2.64E-15	2.63E-13
H-3	8.37E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.25E-16	8.52E-17	9.92E-18	1.73E-16	1.47E-17	8.10E-16	2.55E-15
I-129	5.98E-13	7.48E-18	1.76E-19	7.24E-14	2.06E-15	1.87E-14	4.69E-11	1.02E-11	1.28E-11	9.76E-12	7.89E-13	1.38E-10	2.19E-10
I-130	4.95E-14	1.89E-15	1.73E-17	4.30E-15	3.71E-15	3.58E-17	1.64E-14	5.61E-16	4.20E-16	1.44E-14	3.84E-18	4.08E-15	9.54E-14
I-131	5.00E-13	3.56E-16	9.97E-18	1.16E-14	3.13E-14	1.56E-15	7.44E-12	5.73E-13	7.71E-13	1.65E-12	2.91E-14	6.76E-12	1.78E-11
Xe-131m	0.00E+00	1.57E-20	9.95E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-20
Xe-131m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-132	5.43E-15	1.69E-15	2.83E-17	7.34E-16	9.60E-16	8.04E-19	2.28E-17	1.06E-17	7.24E-18	3.10E-16	1.45E-20	3.84E-18	9.20E-15

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
I-132m	4.16E-15	2.09E-16	0.00E+00	4.42E-16	7.20E-17	3.74E-19	3.44E-18	4.69E-18	3.19E-18	1.38E-16	5.65E-21	5.47E-19	5.03E-15
I-132	1.04E-15	3.15E-16	5.42E-18	1.39E-16	1.82E-16	1.52E-19	4.32E-18	2.01E-18	1.37E-18	5.87E-17	2.74E-21	7.26E-19	1.75E-15
I-132	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.27E-19	2.44E-17	5.64E-18	3.87E-18	1.64E-16	9.07E-21	4.16E-18	2.03E-16
I-133	1.22E-13	5.47E-16	2.75E-17	2.11E-15	9.19E-15	1.31E-16	1.16E-13	2.77E-15	2.31E-15	5.91E-14	3.78E-17	3.47E-14	3.49E-13
Xe-133	0.00E+00	1.69E-19	1.56E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-19
Xe-133m	0.00E+00	2.98E-19	1.11E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.09E-19
Xe-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-134	1.51E-15	1.41E-15	2.62E-17	2.35E-16	3.27E-16	8.53E-20	2.24E-19	9.11E-19	6.19E-19	2.68E-17	1.04E-21	3.45E-20	3.53E-15
I-135	2.39E-14	1.29E-15	2.32E-17	1.95E-15	2.40E-15	9.98E-18	1.82E-15	1.33E-16	9.31E-17	3.74E-15	4.00E-19	3.76E-16	3.58E-14
Xe-135	0.00E+00	1.42E-17	1.26E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-17
Xe-135m	0.00E+00	3.53E-16	6.15E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.59E-16
Xe-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-83m	0.00E+00	5.57E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.57E-20
Kr-85	0.00E+00	3.33E-18	2.60E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.93E-17
Kr-85m	0.00E+00	2.30E-16	2.38E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.54E-16
Kr-85	0.00E+00	1.63E-23	1.30E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.47E-22
Kr-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-87	0.00E+00	7.55E-16	1.19E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.74E-16
Rb-87	4.62E-29	0.00E+00	2.98E-33	0.00E+00	3.10E-29	1.61E-31	2.31E-27	1.33E-28	1.54E-28	1.86E-28	1.54E-29	4.56E-27	7.43E-27
Rb-87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-88	0.00E+00	2.24E-15	3.46E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.27E-15
Rb-88	9.79E-16	6.00E-16	1.99E-16	4.52E-18	4.18E-17	2.16E-21	6.86E-19	5.95E-20	4.16E-20	1.73E-18	3.26E-22	3.98E-22	1.83E-15

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Rb-88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
La-140	6.85E-14	3.08E-15	5.98E-17	3.06E-15	4.28E-15	1.30E-17	1.37E-16	2.08E-16	3.33E-16	6.02E-15	4.22E-20	3.29E-17	8.57E-14
Mn-54	6.82E-14	1.17E-15	0.00E+00	2.02E-13	9.94E-17	5.97E-17	3.46E-15	1.79E-15	4.18E-15	1.47E-14	8.62E-17	2.27E-14	3.18E-13
Mo-99	4.81E-14	2.11E-16	4.23E-17	4.78E-16	5.18E-15	1.17E-17	3.06E-15	9.10E-17	2.05E-16	2.51E-15	6.45E-20	4.66E-16	6.03E-14
Tc-99m	8.60E-17	1.54E-17	4.22E-20	1.18E-18	3.27E-19	3.60E-21	2.73E-19	4.34E-20	6.14E-20	8.29E-19	6.90E-21	1.21E-18	1.05E-16
Tc-99	3.81E-23	0.00E+00	9.33E-28	0.00E+00	6.87E-24	1.30E-25	1.00E-21	2.48E-22	3.48E-22	4.84E-22	3.28E-23	3.98E-20	4.19E-20
Tc-99m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.36E-19	7.57E-17	7.31E-18	1.57E-17	1.07E-16	1.15E-18	3.90E-16	5.98E-16
Na-24	1.92E-14	5.04E-15	6.13E-17	2.01E-15	1.66E-15	1.92E-18	1.91E-15	1.72E-17	1.33E-17	4.20E-16	1.42E-19	6.40E-16	3.09E-14
Nb-95	5.72E-14	1.07E-15	4.91E-19	2.08E-14	3.81E-16	3.19E-17	3.94E-18	6.97E-16	2.51E-15	1.03E-14	1.46E-18	1.99E-18	9.30E-14
Ni-63	2.09E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.73E-17	5.00E-15	8.75E-16	1.52E-15	4.85E-15	8.36E-17	6.18E-17	3.34E-14
Rb-86	8.46E-14	1.30E-16	7.96E-17	1.40E-15	5.13E-14	4.03E-17	5.51E-13	3.64E-14	5.09E-14	5.69E-14	2.09E-15	4.97E-13	1.33E-12
Rb-88	2.68E-16	1.77E-16	5.46E-17	1.46E-18	1.35E-17	6.99E-22	2.22E-19	1.92E-20	1.34E-20	5.61E-19	1.05E-22	1.29E-22	5.15E-16
Ru-103	9.24E-14	6.71E-16	2.44E-18	1.36E-14	4.46E-15	5.28E-17	1.44E-17	5.11E-16	3.55E-16	1.48E-14	1.64E-18	5.25E-15	1.32E-13
Rh-103m	5.83E-17	9.22E-20	0.00E+00	2.75E-22	0.00E+00	3.89E-22	1.41E-19	4.24E-21	2.92E-21	1.25E-19	1.89E-24	1.13E-23	5.86E-17
Ru-106	1.21E-12	0.00E+00	0.00E+00	5.62E-14	4.44E-13	1.10E-15	1.95E-16	7.96E-15	5.70E-15	2.08E-13	1.59E-16	2.55E-13	2.19E-12
Rh-106	0.00E+00	2.90E-16	1.78E-16	5.34E-20	1.51E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.70E-16
Sb-122	6.23E-14	6.21E-16	6.51E-17	8.89E-16	7.02E-15	1.50E-17	1.02E-15	3.01E-16	6.71E-16	8.44E-15	2.16E-19	2.87E-15	8.42E-14
Sb-124	2.64E-13	2.46E-15	4.12E-17	8.62E-14	7.34E-14	1.66E-16	5.37E-15	4.58E-15	1.52E-14	5.90E-14	1.25E-17	1.25E-13	6.36E-13
Sb-125	1.76E-13	6.00E-16	5.26E-18	3.03E-13	2.87E-14	1.99E-16	2.69E-15	3.05E-15	7.93E-15	2.85E-14	5.98E-17	9.04E-14	6.41E-13
Te-125m	4.33E-17	4.79E-21	4.88E-22	2.46E-20	1.79E-20	2.50E-20	3.46E-18	8.94E-18	1.22E-17	8.83E-18	5.28E-19	8.00E-17	1.57E-16
Te-125m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-17	2.91E-15	6.98E-15	1.38E-14	6.84E-15	3.72E-16	1.44E-13	1.75E-13
Sr-89	2.64E-13	1.18E-19	6.85E-17	3.33E-18	1.13E-13	1.60E-16	4.73E-14	4.81E-15	1.66E-14	6.58E-14	3.64E-17	2.27E-14	5.34E-13

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Sr-90	1.21E-12	0.00E+00	1.74E-17	4.10E-20	5.60E-13	3.01E-15	1.37E-12	9.06E-14	3.57E-13	1.45E-12	1.95E-14	3.66E-13	5.43E-12
Y-90	7.51E-16	6.85E-25	8.96E-19	1.13E-25	6.92E-17	1.67E-19	2.42E-18	3.57E-18	7.91E-18	1.01E-16	2.57E-21	4.80E-20	9.36E-16
Sr-91	2.30E-14	9.22E-16	7.34E-17	3.56E-16	1.04E-15	1.58E-18	3.41E-17	1.56E-17	1.27E-17	4.60E-16	3.62E-20	7.39E-18	2.59E-14
Y-91m	2.81E-16	3.19E-16	1.32E-18	5.61E-18	2.15E-18	1.66E-21	4.76E-22	8.89E-21	6.03E-21	2.62E-19	4.95E-24	1.09E-25	6.09E-16
Y-91	1.29E-16	1.65E-21	2.46E-20	5.42E-20	4.10E-17	7.47E-20	3.84E-19	1.63E-18	5.42E-18	2.11E-17	4.38E-21	2.00E-19	1.99E-16
Y-91m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.22E-20	0.00E+00	2.33E-19	1.85E-19	6.85E-18	1.36E-22	0.00E+00	7.31E-18
Sr-92	1.28E-14	1.51E-15	1.45E-17	1.22E-16	7.28E-17	2.68E-19	3.82E-19	2.71E-18	1.95E-18	8.01E-17	6.08E-21	1.96E-19	1.46E-14
Y-92	1.56E-15	4.00E-17	2.19E-17	3.23E-18	6.93E-17	3.93E-20	1.19E-19	6.15E-19	4.27E-19	1.81E-17	3.47E-22	1.17E-22	1.72E-15
Y-92	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.29E-19	0.00E+00	3.57E-18	2.56E-18	1.05E-16	2.05E-21	0.00E+00	1.12E-16
Tc-99m	1.00E-15	1.84E-16	4.93E-19	1.49E-17	4.15E-18	4.56E-20	3.46E-18	5.51E-19	7.78E-19	1.05E-17	8.75E-20	1.54E-17	1.24E-15
Tc-99	3.66E-23	0.00E+00	8.96E-28	0.00E+00	6.61E-24	1.25E-25	9.66E-22	2.39E-22	3.35E-22	4.66E-22	3.16E-23	3.83E-20	4.04E-20
Tc-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.56E-24	1.22E-20	3.02E-21	4.23E-21	5.88E-21	3.99E-22	4.83E-19	5.09E-19
Te-125m	1.21E-13	1.35E-17	1.36E-18	7.45E-17	5.41E-17	7.54E-17	1.05E-14	2.70E-14	3.69E-14	2.67E-14	1.60E-15	2.42E-13	4.66E-13
Te-127	7.62E-15	6.67E-18	1.93E-17	1.28E-18	3.62E-16	5.17E-19	4.52E-17	5.00E-18	3.59E-18	1.36E-16	1.84E-20	1.85E-17	8.22E-15
Te-129	1.59E-15	5.28E-17	3.91E-17	1.33E-18	8.35E-17	1.45E-20	2.92E-19	1.52E-19	1.03E-19	4.48E-18	1.84E-23	1.47E-20	1.77E-15
I-129	2.24E-24	2.77E-29	6.59E-31	2.67E-25	7.60E-27	6.90E-26	1.73E-22	3.77E-23	4.72E-23	3.60E-23	2.91E-24	5.10E-22	8.10E-22
I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-26	0.00E+00	1.09E-23	1.37E-23	1.04E-23	8.45E-25	0.00E+00	3.59E-23
Te-129m	2.86E-13	4.44E-17	2.58E-17	2.13E-15	1.01E-13	1.58E-16	3.65E-14	7.39E-14	1.03E-13	8.67E-14	4.32E-15	6.90E-13	1.38E-12
Te-129	8.35E-16	2.69E-17	2.06E-17	6.32E-19	3.98E-17	6.89E-21	1.39E-19	7.24E-20	4.90E-20	2.13E-18	8.74E-24	7.01E-21	9.25E-16
I-129	2.83E-24	3.49E-29	8.32E-31	3.37E-25	9.60E-27	8.71E-26	2.18E-22	4.75E-23	5.95E-23	4.55E-23	3.68E-24	6.44E-22	1.02E-21
I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.75E-23	0.00E+00	1.61E-23	2.02E-23	1.54E-23	1.25E-24	0.00E+00	7.05E-23
Te-131m	6.28E-14	1.94E-15	1.47E-17	1.68E-15	8.23E-16	1.01E-17	2.67E-15	2.92E-16	2.70E-16	5.01E-15	5.81E-18	3.51E-15	7.90E-14

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
I-131	1.67E-15	1.15E-18	3.33E-20	3.83E-17	1.03E-16	5.14E-18	2.45E-14	1.89E-15	2.54E-15	5.42E-15	9.59E-17	2.23E-14	5.85E-14
Te-131	1.27E-15	4.02E-16	5.64E-17	6.34E-18	3.46E-17	3.82E-21	5.67E-20	7.81E-20	5.27E-20	2.30E-18	5.00E-24	1.03E-21	1.77E-15
I-131	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.02E-17	0.00E+00	1.88E-14	2.56E-14	4.42E-14	9.78E-16	0.00E+00	8.97E-14
Te-132	1.42E-13	3.23E-16	2.72E-18	6.13E-15	3.57E-16	3.74E-17	1.51E-14	3.63E-15	4.29E-15	2.55E-14	1.41E-16	5.06E-14	2.48E-13
I-132	1.70E-15	5.05E-16	8.85E-18	2.26E-16	2.95E-16	2.47E-19	7.02E-18	3.26E-18	2.22E-18	9.54E-17	4.45E-21	1.18E-18	2.84E-15
I-132	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.66E-18	6.37E-18	1.47E-18	1.01E-18	4.28E-17	2.36E-21	1.09E-18	5.54E-17
Te-133m	3.76E-15	1.91E-15	4.88E-17	5.34E-17	7.05E-17	2.75E-20	9.30E-19	5.99E-19	4.05E-19	1.77E-17	5.81E-23	3.73E-20	5.86E-15
I-133	2.89E-15	1.24E-17	6.50E-19	4.93E-17	2.14E-16	3.05E-18	2.70E-15	6.45E-17	5.39E-17	1.38E-15	8.81E-19	8.09E-16	8.18E-15
Te-133	8.90E-16	8.08E-16	6.16E-17	6.30E-18	1.82E-17	1.40E-21	1.32E-20	3.58E-20	2.42E-20	1.06E-18	2.06E-24	1.19E-22	1.78E-15
I-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-19	0.00E+00	1.46E-17	1.23E-17	3.08E-16	2.06E-19	0.00E+00	3.36E-16
Te-134	2.14E-15	6.39E-16	3.96E-18	4.11E-17	1.96E-17	1.20E-20	1.44E-19	1.21E-19	8.19E-20	3.57E-18	9.60E-24	4.37E-21	2.84E-15
I-134	9.81E-16	8.76E-16	1.71E-17	1.51E-16	2.10E-16	5.47E-20	1.44E-19	5.84E-19	3.97E-19	1.72E-17	6.71E-22	2.22E-20	2.25E-15
I-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-20	0.00E+00	1.21E-19	8.26E-20	3.56E-18	1.46E-22	0.00E+00	3.78E-18
Xe-131m	0.00E+00	1.24E-17	7.84E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.03E-17
Xe-133	0.00E+00	5.99E-17	5.49E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.53E-17
Xe-133m	0.00E+00	4.38E-17	1.62E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-17
Xe-133	0.00E+00	2.33E-19	2.17E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.55E-19
Xe-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135	0.00E+00	3.65E-16	3.19E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.97E-16
Cs-135	2.71E-25	0.00E+00	2.71E-29	0.00E+00	1.81E-25	9.34E-28	1.29E-24	4.04E-25	5.46E-25	3.69E-25	2.70E-26	2.34E-23	2.65E-23
Cs-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135m	0.00E+00	1.07E-16	1.77E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-16

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Radionuclide	Inhalation of Plume	Gamma from Plume	Beta from Plume	Gamma from Ground	Beta from Ground	Resuspension	Cow milk	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total
Xe-135	0.00E+00	8.68E-18	7.68E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.45E-18
Xe-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-137	0.00E+00	6.12E-19	4.11E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E-18
Xe-138	0.00E+00	2.32E-16	1.05E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-16
Cs-138	4.29E-16	6.86E-16	3.31E-17	9.38E-18	2.04E-17	1.80E-21	2.18E-22	3.10E-20	2.10E-20	9.12E-19	1.08E-23	6.44E-20	1.18E-15
Cs-138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Zr-95	1.76E-13	1.04E-15	6.98E-18	7.41E-14	1.53E-14	1.12E-16	1.12E-17	1.63E-15	5.39E-15	2.09E-14	1.49E-18	5.30E-18	2.94E-13
Nb-95	3.38E-17	6.18E-19	2.90E-22	1.13E-17	2.08E-19	1.74E-20	2.15E-21	3.81E-19	1.37E-18	5.63E-18	7.99E-22	1.09E-21	5.34E-17
Nb-95m	1.96E-16	5.10E-19	9.16E-20	1.20E-17	1.14E-17	4.97E-20	9.49E-21	7.15E-19	1.92E-18	1.96E-17	5.50E-22	5.09E-22	2.42E-16
Nb-95	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-17	8.53E-19	5.39E-16	1.28E-15	3.63E-15	2.62E-18	2.76E-18	5.46E-15
Total	7.39E-12	6.48E-14	2.15E-15	9.32E-12	2.15E-12	2.72E-14	6.01E-11	1.13E-11	1.47E-11	1.42E-11	8.65E-13	1.59E-10	2.79E-10

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Appendix 7.5: Representative Person Annual Dose from Normal Operational Discharges

Table A7.5.1: Annual dose - Liquid Normal Operational Discharges

Liquid ST radionuclide	Max ST; Bq/y	DCF; $\mu\text{Sv/y}$ per Bq/y	Annual dose; $\mu\text{Sv/y}$
Ag110	3.37E+07	7.88E-24	2.66E-16
Ag-110m	4.18E+09	1.15E-09	4.80E+00
Ba-137m	1.28E+08	1.13E-21	1.45E-13
Ba-140	1.38E+09	3.21E-13	4.44E-04
Br-82	1.00E+04	3.98E-13	3.98E-09
Br-83	5.07E+04	2.37E-15	1.20E-10
Br-84	8.77E+03	1.08E-15	9.47E-12
C-14	6.96E+11	1.85E-10	1.29E+02
Ce-141	9.20E+07	5.48E-14	5.04E-06
Ce-143	5.83E+07	3.86E-15	2.25E-07
Ce-144	2.02E+09	6.68E-13	1.35E-03
Co-58	1.52E+10	2.33E-12	3.54E-02
Co-60	2.20E+10	8.57E-11	1.88E+00
Cr-51	4.34E+09	3.26E-14	1.41E-04
Cs-134	4.10E+09	2.64E-11	1.08E-01
Cs-136	1.19E+09	1.44E-12	1.72E-03
Cs-137	6.93E+09	3.33E-11	2.31E-01
Cs-138	6.40E+04	1.39E-16	8.90E-12
Fe-55	4.73E+09	1.24E-10	5.87E-01
Fe-59	7.36E+08	5.35E-10	3.94E-01
H-3	9.81E+14	3.43E-16	3.36E-01

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Liquid ST radionuclide	Max ST; Bq/y	DCF; $\mu\text{Sv/y}$ per Bq/y	Annual dose; $\mu\text{Sv/y}$
I-129	1.29E+01	1.56E-11	2.02E-10
I-130	2.80E+04	1.11E-14	3.11E-10
I-131	8.28E+08	1.21E-12	1.00E-03
I-132	2.21E+08	3.10E-16	6.84E-08
I-132m	2.44E+03	3.30E-16	8.06E-13
I-133	1.04E+09	3.89E-14	4.06E-05
I-134	5.70E+07	4.50E-17	2.56E-09
I-135	7.05E+08	2.81E-15	1.98E-06
La-140	1.50E+09	1.85E-14	2.78E-05
Mn-54	1.98E+09	5.79E-12	1.15E-02
Mo-99	2.33E+08	1.14E-13	2.65E-05
Na-24	5.83E+08	4.17E-16	2.43E-07
Nb-95	6.44E+08	4.74E-13	3.05E-04
Ni-63	7.04E+09	6.54E-13	4.60E-03
Np-239	6.75E+07	1.78E-13	1.20E-05
P-32	5.52E+07	6.13E-10	3.38E-02
Pr-143	2.00E+07	8.02E-15	1.60E-07
Pr-144	8.28E+08	4.27E-19	3.54E-10
Pu-241	7.73E+05	2.46E-12	1.90E-06
Rb-86	2.38E+06	1.40E-12	3.33E-06
Rb-88	3.77E+06	7.51E-17	2.83E-10
Rh-103m	1.14E+09	7.00E-17	7.95E-08
Rh-106	1.90E+10	4.59E-24	8.71E-14
Ru-103	1.19E+09	4.12E-13	4.92E-04

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Liquid ST radionuclide	Max ST; Bq/y	DCF; $\mu\text{Sv/y}$ per Bq/y	Annual dose; $\mu\text{Sv/y}$
Ru-106	2.18E+10	3.12E-12	6.80E-02
Sb-122	1.26E+07	1.88E-12	2.38E-05
Sb-124	3.59E+09	1.33E-11	4.78E-02
Sb-125	5.97E+09	1.09E-11	6.53E-02
Sr-89	4.91E+07	6.81E-13	3.34E-05
Sr-90	6.75E+06	9.19E-12	6.20E-05
Sr-91	7.97E+06	7.30E-15	5.82E-08
Sr-92	1.73E+02	1.45E-15	2.50E-13
Tc-99m	1.74E+08	3.21E-15	5.58E-07
Te-123m	1.91E+09	2.00E-11	3.81E-02
Te-125m	1.17E+05	1.13E-11	1.32E-06
Te-127	3.06E+03	8.10E-14	2.47E-10
Te-129	1.90E+07	3.83E-15	7.27E-08
Te-129m	2.70E+07	3.45E-11	9.32E-04
Te-131	5.52E+06	4.52E-15	2.50E-08
Te-131m	3.03E+07	2.89E-12	8.77E-05
Te-132	6.13E+07	1.24E-11	7.62E-04
Te-133m	2.14E+05	1.53E-14	3.28E-09
Te-134	2.38E+03	4.06E-15	9.64E-12
W-187	4.29E+07	1.76E-12	7.56E-05
Y-91	2.76E+07	1.22E-13	3.37E-06
Y-91m	5.21E+06	7.45E-17	3.88E-10
Y-93	8.87E+06	1.84E-15	1.63E-08
Zn-65	1.08E+08	4.28E-10	4.61E-02

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Liquid ST radionuclide	Max ST; Bq/y	DCF; $\mu\text{Sv/y}$ per Bq/y	Annual dose; $\mu\text{Sv/y}$
Zr-95	3.99E+08	2.05E-12	8.15E-04
		Total =	137.53

Table A7.5.2: Annual dose - Airborne Normal Operational Discharges

Airborne ST radionuclide	Max ST; Bq/y	DCF; $\mu\text{Sv/y}$ per Bq/y	Annual dose; $\mu\text{Sv/y}$
Ag-110m	2.96E+06	2.96E-11	8.76E-05
Ar-41	1.26E+13	5.06E-15	6.35E-02
Ba-137m	2.83E+04	5.96E-19	1.69E-14
Ba-139	1.04E+04	2.25E-15	2.33E-11
Ba-140	1.55E+06	6.54E-13	1.01E-06
Br-82	4.34E+06	3.03E-13	1.31E-06
Br-83	2.93E+07	2.32E-15	6.80E-08
Br-84	1.29E+07	4.28E-15	5.53E-08
C-14	1.59E+13	1.66E-12	2.65E+01
Ce-141	3.99E+06	2.00E-13	7.97E-07
Co-57	2.51E+06	1.25E-13	3.14E-07
Co-58	6.36E+08	4.15E-13	2.64E-04
Co-60	7.48E+08	2.03E-11	1.52E-02
Cr-51	2.98E+07	8.48E-15	2.52E-07
Cs-134	5.83E+08	4.83E-11	2.82E-02
Cs-136	1.01E+07	2.07E-12	2.09E-05
Cs-137	5.23E+08	5.14E-11	2.69E-02

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Airborne ST radionuclide	Max ST; Bq/y	DCF; $\mu\text{Sv/y}$ per Bq/y	Annual dose; $\mu\text{Sv/y}$
Cs-138	2.52E+05	5.36E-15	1.35E-09
Fe-59	8.62E+06	5.28E-13	4.55E-06
H-3	5.37E+13	6.62E-15	3.55E-01
I-129	5.52E+03	1.56E-09	8.61E-06
I-130	5.54E+06	1.53E-13	8.48E-07
I-131	1.84E+09	4.97E-11	9.13E-02
I-132	1.48E+10	1.36E-14	2.01E-04
I-132m	8.43E+05	7.83E-15	6.60E-09
I-133	7.05E+09	6.58E-13	4.64E-03
I-134	2.42E+10	7.44E-15	1.80E-04
I-135	1.41E+10	3.98E-14	5.61E-04
Kr-83m	4.80E+08	1.99E-19	9.55E-11
Kr-85	1.50E+15	3.79E-17	5.69E-02
Kr-85m	2.15E+12	8.46E-16	1.82E-03
Kr-87	6.13E+11	2.82E-15	1.73E-03
Kr-88	1.53E+12	1.10E-14	1.69E-02
La-140	4.49E+02	9.20E-14	4.13E-11
Mn-54	1.75E+07	1.24E-12	2.17E-05
Mo-99	1.84E+05	7.99E-14	1.47E-08
Na-24	6.38E+05	6.01E-14	3.84E-08
Nb-95	1.28E+07	2.08E-13	2.67E-06
Ni-63	1.55E+07	8.07E-14	1.25E-06
Rb-86	2.19E+04	4.18E-12	9.14E-08
Rb-88	3.82E+05	8.61E-16	3.29E-10

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Airborne ST radionuclide	Max ST; Bq/y	DCF; $\mu\text{Sv/y}$ per Bq/y	Annual dose; $\mu\text{Sv/y}$
Ru-103	5.21E+06	2.14E-13	1.12E-06
Ru-106	2.40E+05	2.43E-12	5.82E-07
Sb-122	2.12E+05	8.07E-14	1.71E-08
Sb-124	5.99E+05	1.07E-12	6.41E-07
Sb-125	1.87E+05	2.14E-12	4.02E-07
Sr-89	4.91E+07	8.49E-13	4.17E-05
Sr-90	1.93E+07	3.59E-11	6.93E-04
Sr-91	8.55E+02	2.53E-14	2.17E-11
Sr-92	1.46E+02	1.59E-14	2.32E-12
Tc-99m	4.85E+04	1.62E-15	7.85E-11
Te-125m	7.40E+03	5.28E-13	3.91E-09
Te-127	2.54E+03	6.67E-15	1.69E-11
Te-129	2.38E+03	1.46E-15	3.47E-12
Te-129m	1.37E+05	1.41E-12	1.93E-07
Te-131m	1.38E+04	4.02E-13	5.54E-09
Te-132	3.39E+04	2.83E-13	9.59E-09
Te-133m	1.68E+04	2.88E-14	4.84E-10
Te-134	3.79E+03	8.75E-15	3.32E-11
Xe-131m	6.75E+14	5.23E-17	3.53E-02
Xe-133	1.09E+14	2.19E-16	2.40E-02
Xe-133m	3.99E+13	1.74E-16	6.93E-03
Xe-135	3.27E+13	1.33E-15	4.35E-02
Xe-135m	2.45E+12	4.15E-16	1.02E-03
Xe-137	9.20E+11	2.60E-18	2.39E-06

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Airborne ST radionuclide	Max ST; Bq/y	DCF; $\mu\text{Sv/y}$ per Bq/y	Annual dose; $\mu\text{Sv/y}$
Xe-138	9.20E+11	3.64E-15	3.35E-03
Zr-95	3.57E+06	6.92E-13	2.47E-06
		Total =	27.32

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Appendix 7.6: Assumptions and Parameter Values used in the Dose Assessment of Short-Term Discharges during Minor Occurrences

1. Introduction

The representative person dose result from minor occurrences and 24 h discharge period was calculated as follows:

- selecting conservative atmospheric dispersion condition for a 24 h discharge period;
- dose from iodine, noble gas, fission and activation radionuclides using the *ECOSYS* code based on a conservative dispersion coefficient at a distance 3 km;
- dose from C-14 and H-3 using the *PC-CREAM 08* code; conservative atmospheric stability conditions and applying a factor to the dose results to account for the short-term exposure of 24 h.

2. Atmospheric dispersion coefficient, χ/Q

The meteorological conditions selected for the short-term discharge during 24 h were based on data included in **Section 5.8** (Meteorology). It is assumed that the wind is ENE, the same direction for which the representative person dose was calculated and resulting in the highest dose for normal continuous discharges from the NNPS.

A conservative dispersion coefficient, $\chi/Q = 5\text{E-}06 \text{ s/m}^3$, was selected from data highlighted in **Table A7.6.1** for the *ECOSYS* calculations. The highest value is $2.82\text{E-}06 \text{ s/m}^3$ in the ENE direction at a distance of 3 km. ENE is the direction corresponding to the St. Francis Bay location where the highest DCFs were calculated. The nearest farm is 3 km away but due north (0 degrees) (**Subsection 7.9**). A dispersion factor equal to $5\text{E-}06 \text{ s/m}^3$ was used assuming that the exposure occurs at the nearest farm.

Table A7.6.1: TSSR Section 5.8 - Site Airborne Dispersion Coefficient $\chi/Q \text{ (s/m}^3\text{)}$

Distance (m)	Highest 24-Hourly		
	800 m	3000 m	8000 m
N	1.87E-05	1.78E-06	2.36E-06
NNE	2.17E-05	1.57E-06	2.22E-06
NE	2.34E-05	2.00E-06	2.22E-06
ENE	4.50E-05	2.82E-06	2.96E-06
E	8.68E-05	8.49E-06	2.86E-06
ESE	1.83E-05	5.76E-06	7.32E-07
SE	7.60E-06	1.09E-06	4.12E-07
SSE	9.21E-06	9.84E-07	3.24E-07

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Distance (m)	Highest 24-Hourly		
	800 m	3000 m	8000 m
S	4.85E-06	6.58E-07	2.01E-07
SSW	6.51E-06	9.86E-07	2.46E-07
SW	7.05E-06	9.10E-07	2.29E-07
WSW	1.64E-05	1.19E-06	2.60E-07
W	1.41E-05	2.34E-06	2.56E-07
WNW	3.05E-05	4.39E-06	2.19E-06
NW	4.09E-05	3.51E-06	8.02E-07
NNW	2.60E-05	3.64E-06	5.52E-07

Table A7.6.2: Data from TSSR Section 5.8 (Meteorology) - Comparison of Atmospheric Stability Classification Table

Stability Class	Atmospheric Stability Frequency of Occurrence	
	Delta-T Method [8m/2m] Vertical Stability	Sigma-Theta Method Horizontal [9m] Stability
A	55.97%	3.85%
B	1.65%	1.83%
C	1.58%	4.85%
D	7.41%	40.67%
E	11.28%	45.89%
F	9.58%	2.90%
G	12.53%	0.01%

The dose calculations for C-14 and H-3 were conservatively based on category F stability for the duration of 24 h in the ENE direction. The *PC-CREAM 08* meteorological data file is shown in **Table A7.6.3**. The dose results are included in **Table A7.6.7**.

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Table A7.6.3: PLUME Meteorology Data

TP Weather ST															
1															
16, 11.25															
A, B, C, D, E, F, C Rain, D Rain															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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3. ECOSYS dose calculation – minor occurrence short-term source term and dose results

The Thyspunt source term based on the UK EPR selection of nuclides, and the integrated air concentration are as follows (UK EPR data included for reference):

Table A7.6.4: ECOSYS Source Terms

Nuclide	TSSR at 3 km ENE; X/Q = 5E-06			Single UK EPR at 800 m; X/Q = 1E-04		
	Bq released in 24h	Bq/s	Bq/m ³	Bq released in 24h	Bq/s	Bq/m ³
I-131	1.84E+09	5.83E+01	2.92E-04	1.82E+08	2.11E+03	1.05E-02
Kr-85	1.50E+15	4.75E+07	2.38E+02	6.95E+11	8.04E+06	4.02E+01
Xe-133	1.09E+14	3.45E+06	1.73E+01	3.16E+12	3.66E+07	1.83E+02
Xe-135	3.27E+13	1.04E+06	5.18E+00	9.90E+11	1.15E+07	5.73E+01
Ar-41	1.26E+13	3.99E+05	2.00E+00	1.45E+11	1.68E+06	8.39E+00
Xe-131m	6.75E+14	2.14E+07	1.07E+02	1.50E+10	1.74E+05	8.68E-01
I-133	7.05E+09	2.23E+02	1.12E-03	2.18E+08	2.52E+03	1.26E-02
Co-58	6.36E+08	2.02E+01	1.01E-04	4.34E+07	5.02E+02	2.51E-03
Co-60	7.48E+08	2.37E+01	1.19E-04	5.12E+07	5.93E+02	2.96E-03
Cs-134	2.42E+10	7.67E+02	3.83E-03	3.98E+07	4.61E+02	2.30E-03
Cs-137	5.23E+08	1.66E+01	8.29E-05	3.57E+07	4.13E+02	2.07E-03

ECOSYS includes the following radionuclides in its built-in data file:

Ba-140, Ce-141, Ce-144, Cs-124, Cs-136, Cs-137, I-129, I-131, I-133, Kr-85m, Kr-87, Kr-88, Mn-54, Mo-99, Nb-95, Pu-239, Ru-103, Ru-106, Sr-89, Sr-90, Sr-91, Te-129, Te-132/I-132, Xe-133, Xe-135, Zn-65 and Zr-95.

Since Kr-85, Co-58, Co-60 and Ar-41 are not available in ECOSYS surrogate nuclides were selected and included in the dose assessment. Their decay half-lives and ICRP dose coefficients provide a conservatism in the dose result.

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Table A7.6.5: Data for Surrogate Nuclides

Inert gas radionuclide	T1/2	Effective dose rate per unit integrated air concentration; Sv/d per Bq/m ³	TSSR Bq/y	Assumed Bq/y
Kr-85m	4.48 h	5.9E-10	2.15E+12	2.15E+15
Kr-85	10.7 y	2.2E-11	1.50E+15	
Radionuclide	T1/2	Adult – Ingestion committed effective dose; Sv/Bq	Adult – Inhalation committed effective dose; Sv/Bq	TSSR Bq/y
Co-58	70.8 d	7.4E-10	2.1E-09	6.36E+08
Co-60	5.27 y	3.4E-09	3.1E-08	7.48E+08
Cs-134	2.06 y	1.9E-08	2.0E-08	2.42E+10

Table A7.6.6: ECOSYS Dose Results

Nuclide	Total; mSv	Ingestion; mSv	Inhalation; mSv	Cloud; mSv	Ground shine; mSv	Skin/clothes; mSv
I-131	5.39E-06	5.24E-06	9.36E-08	4.29E-10	6.11E-08	5.68E-10
Xe-133	1.94E-06	0	0	1.94E-06	0	0
Kr-85m	1,89E-04	0	0	1,89E04	0	0
Xe-135	4.92E-06	0	0	4.92E-06	0	0
I-133	8.17E-07	5.76E-07	7.42E-08	2.61E-09	1.62E-07	2.35E-09
Cs-134	8.62E-06	7.57E-06	5.4E-07	2.38E-08	4.55E-07	3.11E-08
Cs-137	1.25E-07	1.13E-07	8.15E-09	1.93E-10	3.85E-09	2.42E-10
Co-58	8.62E-06	7.57E-06	5.4E-07	2.38E-08	4.55E-07	3.11E-08
Co-60	8.62E-06	7.57E-06	5.4E-07	2.38E-08	4.55E-07	3.11E-08

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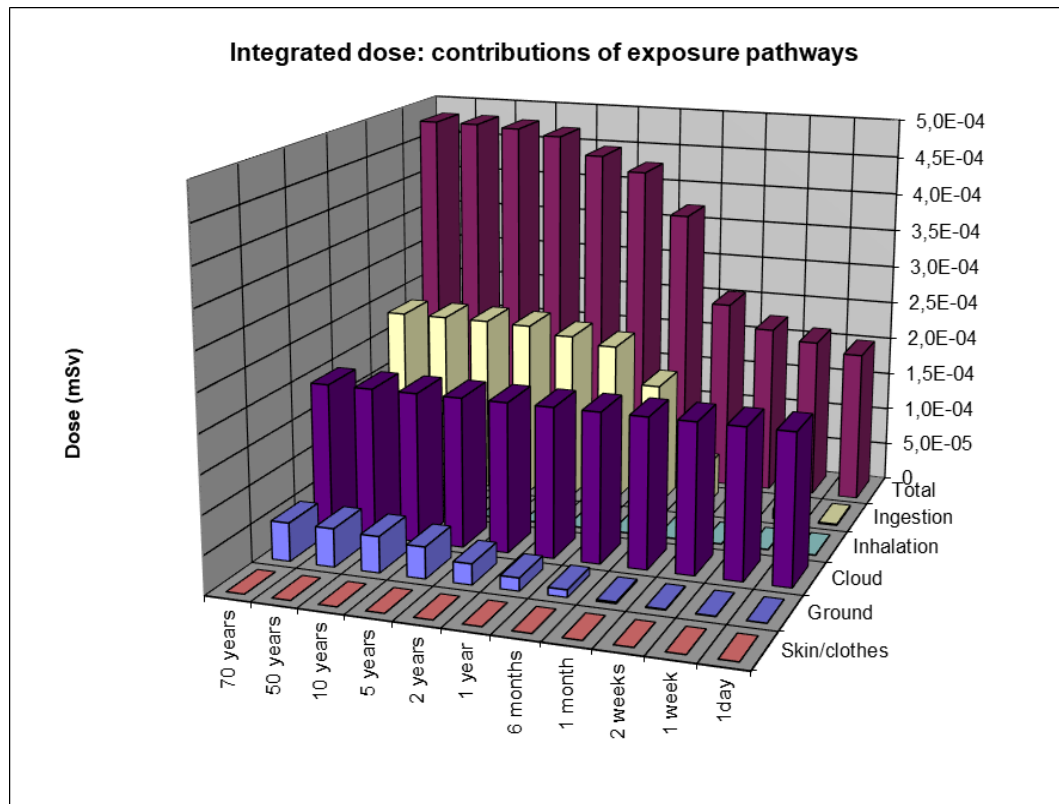


Figure A7.6.1: ECOSYS Integrated Dose as a Function of Time

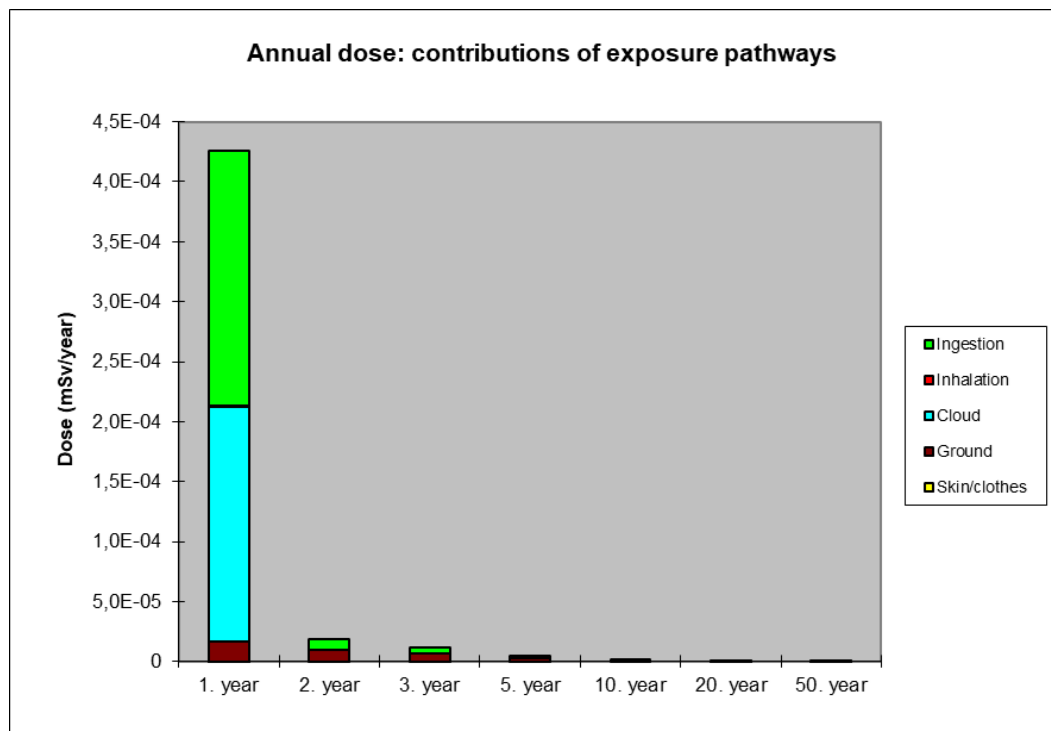


Figure A7.6.2: ECOSYS Dose as a Function of Exposure Pathways

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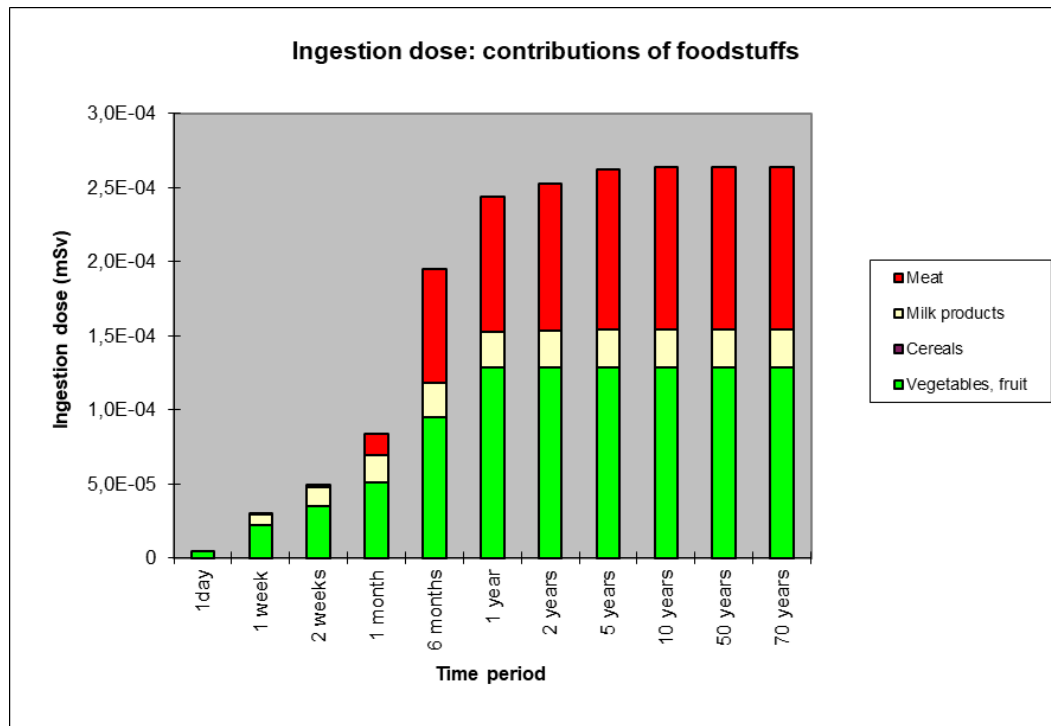


Figure A7.6.3: ECOSYS Dose as a Function of Types of Food Consumption Time

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Table A7.6.7: PC-CREAM 08 Individual doses (μSv) due to atmospheric discharges. Age: Adult Time: 1 year from: Stack 1

Individual doses (μSv) due to atmospheric discharges. Age: Adult Time: 1 year from: Stack 1													
Nuclide	Source term	Inhalation of Plume	Cow liver	Cow meat	Cow milk	Cow milk products	Fruit	Grain	Green vegetables	Root vegetables	Sheep meat	Total_ 1 year	Final_24 h
C-14	(1.59E+13 Bq/y)	1.27E+02	2.54E+00	1.31E+02	1.66E+02	4.88E+02	8.87E+01	4.90E+02	1.12E+02	2.76E+02	2.36E+02	2.12E+03	5.80
H-3	(5.37E+13 Bq/y)	5.78E+00	2.91E-02	1.50E+00	7.32E+00	1.58E+00	1.75E+00	2.67E-01	2.21E+00	5.42E+00	2.70E+00	2.85E+01	0.08
Total		1.32E+02	2.57E+00	1.33E+02	1.73E+02	4.89E+02	9.05E+01	4.90E+02	1.14E+02	2.81E+02	2.38E+02	2.14E+03	5.86

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Appendix 7.7: Biota Concentration and Sediment Distribution of Radionuclides in the Marine Environment

Table A7.7.1 lists probability distribution functions for concentrations factors in biota and sedimentation distribution coefficients for the marine environment provided in the *ERICA* code. It demonstrates the variability in these important parameters.

Table A7.7.1: Examples of Probability Distribution Functions of Marine Organism Concentration Factors and Sediment Distribution Coefficients

Element	Organism	CF (Bq/t per Bq/m ³)	Probability Distribution Function
Ag	Benthic mollusc	3.20E+04	lognormal(32000.0,44000.0,0.0,Infinity)
C	Benthic mollusc	1.00E+04	exponential(10000.0,0.0,Infinity)
Co	Benthic mollusc	5.10E+03	lognormal(5100.0,9900.0,0.0,Infinity)
Cs	Benthic mollusc	6.60E+01	lognormal(66.0,60.0,0.0,Infinity)
Ag	Crustacean	1.60E+04	exponential(16000.0,0.0,Infinity)
C	Crustacean	1.00E+04	exponential(10000.0,0.0,Infinity)
Co	Crustacean	1.80E+03	lognormal(1800.0,1900.0,0.0,Infinity)
Cs	Crustacean	4.10E+01	lognormal(41.0,83.0,0.0,Infinity)
Ag	Pelagic fish	2.90E+03	lognormal(2900.0,4100.0,0.0,Infinity)
C	Pelagic fish	1.20E+04	exponential(12000.0,0.0,Infinity)
Co	Pelagic fish	5.60E+03	lognormal(5600.0,15000.0,0.0,Infinity)
Cs	Pelagic fish	8.60E+01	lognormal(86.0,120.0,0.0,Infinity)
Ag	Benthic fish	2.90E+03	lognormal(2900.0,4100.0,0.0,Infinity)
C	Benthic fish	1.20E+04	exponential(12000.0,0.0,Infinity)
Co	Benthic fish	5.60E+03	lognormal(5600.0,15000.0,0.0,Infinity)
Cs	Benthic fish	8.60E+01	lognormal(86.0,120.0,0.0,Infinity)
Element	KD (Bq/t per Bq/m ³)		Probability distribution function
Ag	1.00E+04		exponential(10000.0,0.0,Infinity)
C	1.00E+03		exponential(1000.0,0.0,Infinity)
Co	3.00E+05		exponential(300000.0,0.0,Infinity)
Cs	4.00E+03		exponential(4000.0,0.0,Infinity)