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2.1 List of Abbreviations and Acronyms

ADMS	Atmospheric Dispersion Modelling System
EA	Environment Agency (UK)
ERICA	Environmental Risk from Ionising Contaminants: Assessment and Management
GDA	Generic Design Assessment
IRA	Initial Radiological Assessment
IRAT	Initial Radiological Assessment Tool
NHB	Non-Human Biota
P&ID	Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs
PC-CREAM	Personal Computer version of Consequences of Radiological Emissions Assessment Methodology
PCER	Pre-Construction Environmental Report
UK HPR1000	UK version of the Hua-long Pressurised Reactor

2.2 Introduction

According to the requirements set out in the *Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs (P&ID)*, Reference [1], published by the Environment Agency (EA), there is a need to assess the radiological and non-radiological impact to members of the public and the environment at a generic site. This chapter provides the generic site characteristics (terrestrial and aquatic) and definitions of the human and non-human receptors that could be exposed to radioactivity discharged from the UK version of the Hua-long Pressurised Reactor (UK HPR1000). This information is used in the assessments of radiological dose and emissions to air. Together, these descriptions help to fulfil the requirements in Reference [1].

One of fundamental objective of the UK HPR1000 Generic Design Assessment (GDA) project is that the generic UK HPR1000 could be constructed, operated and decommissioned in the UK, on a site bounded by the generic site envelope, in a way that is safe, secure and protects the environment, Reference [2]. This is supported by the high level claim which in turn, aligns with the route map to provide information describing key aspects of a generic UK site that bounds the suitable locations for a nuclear power plant with the generic site characteristics of the UK HPR1000.

This chapter supports the high level claim with the Level 2 Claim 1.2: The

characteristics adopted in the environmental assessment reflect those of the Generic Site.

The assessment methods used to estimate the potential radiological impact of the reactor design on the environment are provided in a separate part of this PCER (see PCER Chapter 7). The conventional environmental impact assessment method can be found in PCER Chapter 8.

This chapter has interfaces with the following chapters:

T- 2.2-1 Interface with Other Chapters

Chapter	Interface Relationship
PCER Chapter 7 Radiological Assessment	This chapter provides generic site data which supports the radiological assessment detailed in PCER Chapter 7.
PCER Chapter 8 Conventional Impact Assessment	This chapter provides meteorological data which supports the conventional environmental impact assessment detailed in PCER Chapter 8.

2.3 Regulatory Context

The EA regulates nuclear licenced sites, primarily under *The Environmental Permitting (England and Wales) Regulations 2016 (as amended)* Reference [3]. The information which is needed to be included in a GDA submission is specified in the P&ID, Reference [1].

The P&ID sets the following requirement with respect to the Generic Site Description, Reference [1]:

<p><i>General information relating to the requesting party and the design.</i></p> <p><i>Include:</i></p> <ul style="list-style-type: none"> <i>Description and characteristics of the generic site (or sites) that the requesting party will use to provide its dose assessment (see Chapter 7). A range of generic sites might be chosen with coastal, estuarine and inland characteristics.</i>
--

The approach to the generic site also considers the follow relevant Regulation Environmental Principles, Reference [4]:

Principle SEDP1 – General Principle for Siting of New Facilities

When evaluating sites for a new facility, account should be taken of the factors that might affect the protection of people and the environment from radiological hazards and the generation of radioactive waste.

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Principle SEDP2 –Migration of Radioactive Material in the Environment

Data should be provided to allow the assessment of rates and patterns of migration of radioactive materials in the air and the aquatic and terrestrial environments around sites.

2.4 Characteristics of the Generic Site

2.4.1 Overview of Generic Site

The UK requires new nuclear power stations to provide reliable electricity supplies and a secure and diverse energy mix as the UK makes the transition to a low carbon economy. In the UK Government's *National Policy Statement for Nuclear Power Generation (EN-6)*, Reference [5], eight potential sites have been identified which are located on the coast or on large estuaries. The parameters used in this chapter are based primarily on the EA's recommended publications and guidelines, which are generic site data and are suitable for potential sites identified in EN-6, Reference [5].

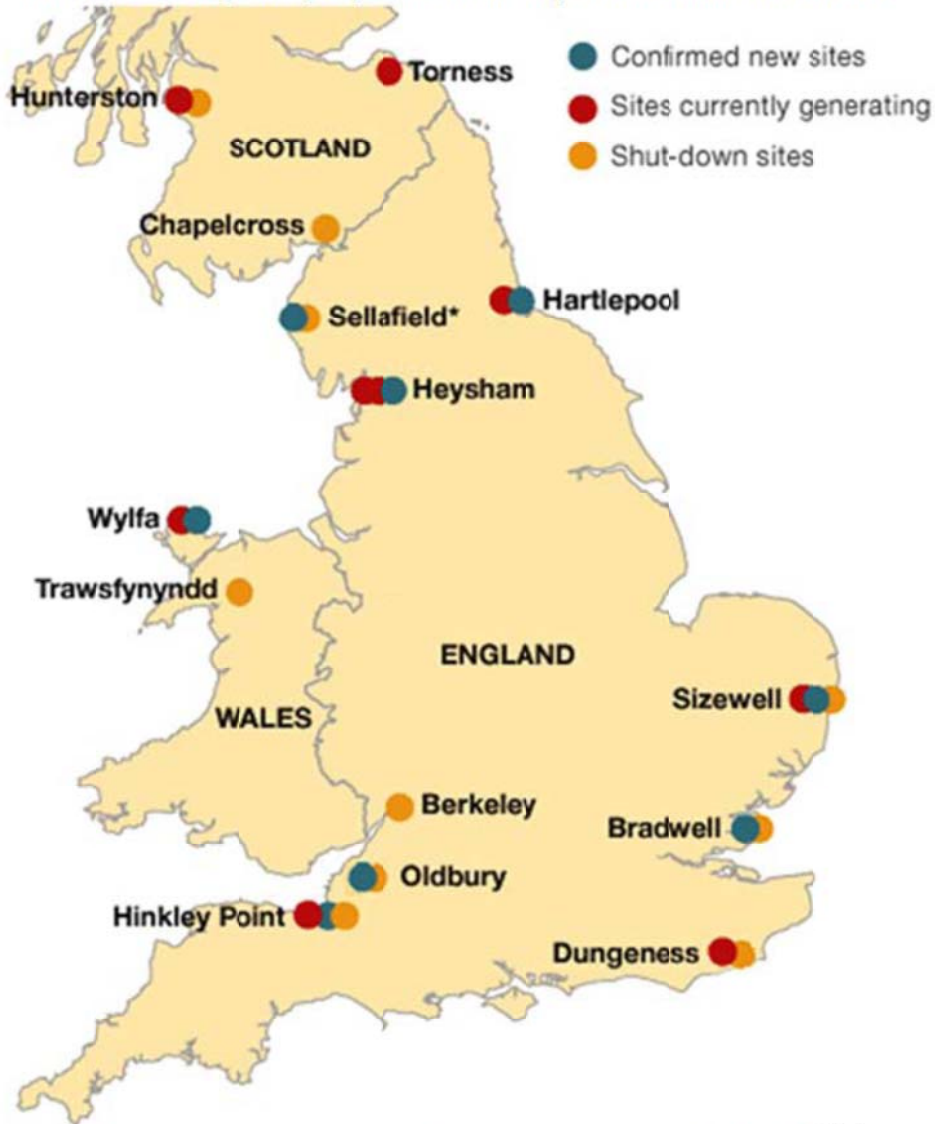
The eight potential sites identified in EN-6, Reference [5] are shown as blue dots in F-2.4-1. The red dots in F-2.4-1 are the current operating nuclear power stations, and the orange dots are the nuclear power stations undergoing decommissioning (shut-down sites).

The generic site for the UK HPR1000 does not represent any particular location in the UK, but represents the envelope of the potential UK site conditions. This is to ensure that the GDA is broadly representative of UK potential sites.

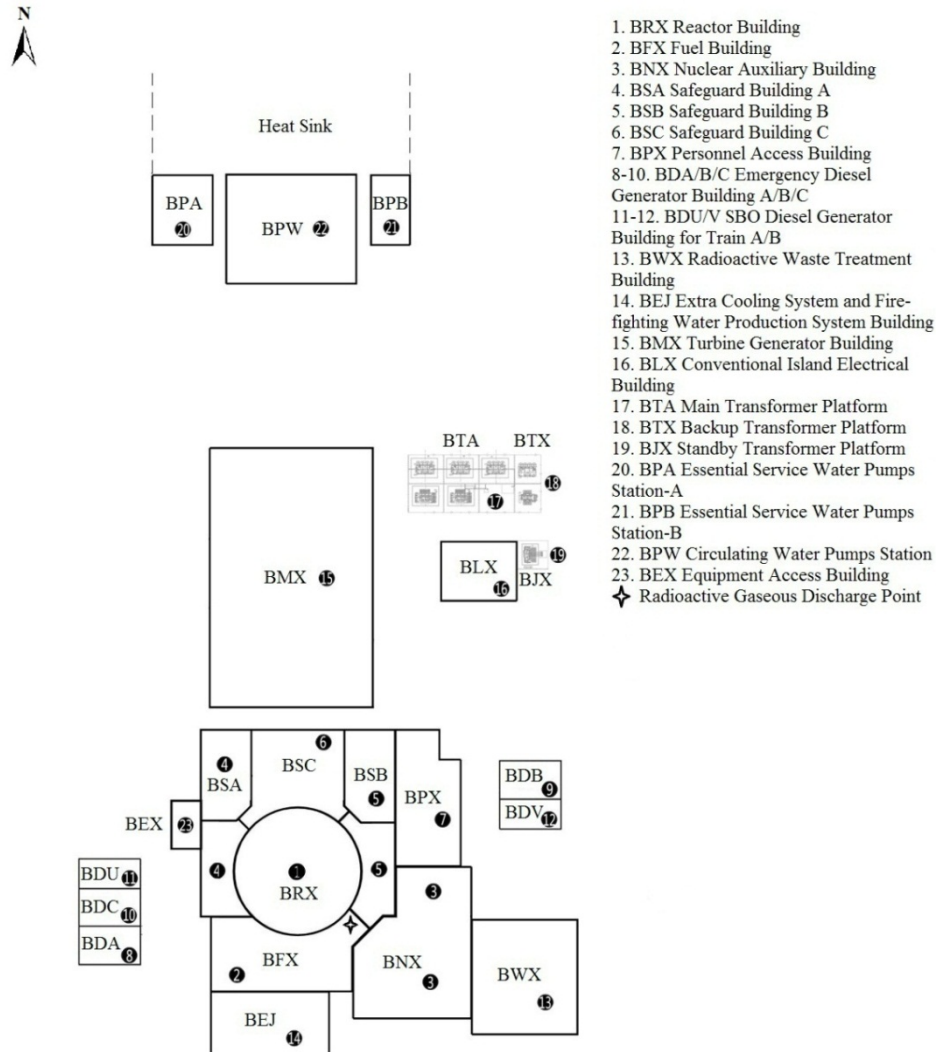
The UK HPR1000 adopts a single-unit layout with no planned discharges to groundwater. The final layout of the UK HPR1000 is site specific, as it is impacted by the topography, geology, meteorology, transport conditions and other factors of the future site and will be designed to have a low impact to the environment, to be safe, economical to operate, and as straightforward as possible to construct, operate, maintain and decommission.

F-2.4-2 shows the general layout of main buildings of the UK HPR1000 including the Nuclear Island, Conventional Island and balance of plant within the GDA scope, Reference [6]. The distance from the facilities to the members of the public is expected to exceed 100m on the basis of existing practices. It is therefore conservative to assume that the site boundary of the generic site is 100m.

Sites of existing and proposed nuclear power stations in the UK



F-2.4-1 Proposed Sites for New Nuclear Power Stations (Blue dot), Reference [7]



F-2.4-2 General Layout of the UK HPR1000

The main assumptions about the generic site are:

- The site is in a coastal or estuarine location and the topography of the site is flat;
- There is no water extraction from aquifers and no standing water at the site;
- There are no freshwater bodies on or adjacent to the site;
- The nearest human receptors are assumed to be a fisherman family and local resident family;
- Discharge routes are assumed to be gaseous aerial discharges and liquid discharges to the marine/estuarine environment adjacent to the site;

2.4.2 The Methodology of the Dose Assessment

Multiple assessment tools have been selected to ensure all of the dose assessment requirements of the P&ID are fulfilled. Information on these is provided below.

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2.4.2.1 IRAT

The Initial Radiological Assessment Tool (IRAT) methodology, Reference [8] and [9], is a staged approach developed by the EA to assess doses to the public, based on conservative assumptions.

This initial radiological assessment methodology is applied in the following three main stages:

- a) Stage 1 – Initial radiological assessment using default data. If the assessed dose is $> 20 \mu\text{Sv/y}$, then proceed to Stage 2;
- b) Stage 2 – Initial radiological assessment using refined data. If the assessed dose is $> 20 \mu\text{Sv/y}$, then proceed to Stage 3;
- c) Stage 3 – Determine the need for separate site-specific assessment.

Stages 1 and 2 are carried out in PCER Chapter 7 Radiological Assessment using default data in Reference [8] and [9]. The Stage 3 assessment is undertaken using more realistic site condition information, and is presented in PCER Chapter 7. The parameters presented in Reference [6] are relatively conservative for all of the potential sites and are also appropriate for carrying out the Stage 3 assessments.

2.4.2.2 Personal Computer version of Consequences of Radiological Emissions Assessment Methodology (PC-CREAM) 08

PC-CREAM08, Reference [10], is a well-developed and established dose modelling tool within the UK for the assessment of the potential dose to people.

2.4.2.3 Atmospheric Dispersion Modelling System (ADMS) 5

ADMS 5 is a practical, short-range air dispersion model that simulates a wide range of buoyant and passive releases to atmosphere. It is used to support short-term assessments, and is also capable of calculating the cloud gamma dose rate. The simulated atmospheric diffusion module in ADMS is consistent with Reference [11].

2.4.2.4 Environmental Risk from Ionising Contaminants: Assessment and Management (ERICA)

ERICA, Reference [12], is used within the UK for conducting dose assessments to Non-Human Biota (NHB). It has a tiered approach to assessing the radiological risk to terrestrial, freshwater and marine biota.

2.4.2.5 Ar-Kr-Xe Tool

ERICA does not contain data for noble gases, therefore the Ar-Kr-Xe tool, Reference [13], is used to supplement the data from the ERICA assessment for calculating the dose of noble gases to NHB.

This tool is a variant to the R&D 128 tool developed by the EA. It includes the ability

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to calculate doses for all the environmentally relevant Ar, Kr and Xe isotopes and covers the original R&D 128 organisms and the International Commission on Radiological Protection reference animals and plants that the ERICA assessment considers.

2.4.3 Terrestrial Ecosystem

The environment around the generic site is described in following sub-chapters. At the GDA stage, the parameters used to describe the generic site are taken mainly from UK publications or guidance as relevant to the potential sites (shown in F-2.4-1).

2.4.3.1 Meteorological Parameters

Meteorological data is used in the gaseous pathway impact assessment and the conventional air emission assessment. Different meteorological data are used for the annual dose assessment and the short term dose assessment.

The meteorological parameters which are used during the GDA phase to define the site characteristics are presented in T-2.4-1 below. Site-specific data is not available at the time of submission of this document. Further information is presented below on basis for the selection of the parameters presented in T-2.4-1.

For the annual assessment, data is taken from NRPB-R91, Reference [14]. This shows the typical annual average frequency of each Pasquill stability category, ranging from 50% D to 80% D, and presents the expected ground level concentrations resulting from a continuous release as a function of distance and effective stack height (at 50% D, 55% D, 60% D, 65% D, 70% D, 75% D and 80% D meteorological conditions (shown in Figure 34 to Figure 40 of Reference [14])). The data presented shows that an increase in stability category D will reduce the ground level concentration, with the concentration at the 50% D condition about a factor of 2 higher than that at the 80% D condition. The 65% D condition has been selected for the assessments undertaken at the GDA stage, as the stability parameter that is representative of the coastal location occupied by the UK HPR1000. This value is considered to be a relatively conservative value. The other parameters used for the annual assessment are wind speed 5 m/s, boundary layer height 800 m and a continuous rainfall rate of 1 mm/h (T-2.4-1).

For the short-term release assessment, the realistically conservative meteorological conditions presented in Reference [11] are used, which are conservative enough but not extremely as Reference [11] shows that *adoption of these meteorological conditions is shown to result in representative group doses at 1 km downwind of the release point, being in the upper part of the overall distribution, generally around the 70th percentile.*

The meteorological conditions used for the assessment are atmospheric stability category D, wind speed 3 m/s, boundary layer height 800 m and a continuous rainfall

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rate of 0.1 mm/h. These values are considered to be disadvantageous case and therefore provide a more conservative evaluation, Reference [11].

T-2.4-1 Atmospheric Conditions Used for Gaseous Pathway Assessments in Reference [6]

Parameter	Proposed Value for Annual (Stage 1&2) and Collective Doses	Proposed Value for Annual (Stage 3)	Proposed Value for Short-term Release Assessment
Pasquill Stability	50%D*	65%D [∞]	D ^{∞∞}
Wind Speed at 10 m height (m/s)	5	5	3
Wind Rose	Uniform	Uniform	Wind blows towards critical group and food crop
Rainfall Rate (mm/h)	1	1	0.1
Boundary layer depth (m)	800	800	800

* Data taken from Reference [9], the range of values for Pasquill category and wind speed is same as Reference [14].

[∞] Data taken from Reference [14], the range of values for Pasquill category and wind speed is same as Reference [14].

^{∞∞} Data taken from Reference [11].

2.4.3.2 Type of Land Use

It is assumed that an agricultural area is present around the UK HPR1000 generic site, which is typical of the 8 potential sites identified in EN-6, Reference [5]. The surface roughness value used for defining agricultural areas is 0.3 and the soil type is generic wet, Reference [6].

2.4.3.3 Habit Data for Gaseous Discharges

Habit data of local resident family exposure group are used to estimate the dose from intakes of radionuclides and the external radiation from gaseous discharges. The habit data relates to the exposure pathways from releases to air of the local resident family exposure group. These habits can vary widely from one individual to another and also in the same individual from one time to another.

Relevant exposure pathways are identified as:

- a) Inhalation of radionuclides in the effluent plume;
- b) External irradiation from radionuclides in the effluent plume and deposited to the ground; and,
- c) Consumption of terrestrial food incorporating radionuclides deposited to the ground.

The habit data used in the GDA are summarised in T-2.4-2 to T-2.4-4 below.

For the Stage 1 and 2 assessment, the terrestrial food ingestion rates are the default data used in PC-CREAM08. The data is general and is considered adequate in circumstances where doses are not expected to approach limits or constraints, and where regional variations in habits are likely to be small, Reference [10].

The high and average levels of the terrestrial food consumption rates (from PC-CREAM08) are presented in T-2.4-2. The relative contributions of the food consumption rates vary considerably between individuals, with distinct regional variations. The appropriate food consumption rates are determined according to the overall objective of the assessment, with the average intake rate used to determine the dose to average individuals. The high consumption group figures are required for dose or risk estimates for comparison with limits or constraints. The 97.5th percentile data is appropriate for most assessment purposes where critical groups are considered, and this approach is consistent with Reference [15].

The “top two” approach defined in Reference [16] is used for setting out the more realistic terrestrial food consumption rates. The “top two” terrestrial food consumption rates are identified based on 100% high consumption rates and used for stage 3 (representative person and short-term dose assessments). The habit data which use the “top two” approach for different age groups are listed in T-2.4-2.

T-2.4-2 Food Consumption Data of Local Resident Family in Reference [6] and Reference [16]

Food Consumption Rates (kg/y)	High Consumption Data			Average Consumption Data			Values used in “top two” approach*		
	Adult	Child	Infant	Adult	Child	Infant	Adult	Child	Infant
Green vegetables	80	35	16.8	59.4	15	13.7	35	15	5
Root vegetables	130	95	45	68.4	50	15	130	95	45
Fruit	75	50	35	32.9	15.2	9	20	15	9
Grain **	100	75	30	50	45	15	---	---	---
Sheep meat	25	10	3	8	4	0.8	8	4	0.8
Sheep liver	10	5	2.75	2.75	1.5	0.5	2.75	1.5	0.5
Cow meat	45	30	10	15.8	15	3	15	15	3
Cow liver	10	5	2.75	2.75	1.5	0.5	2.75	1.5	0.5
Cow milk	240	240	320	95	110	130	240	240	320
Cow milk products**	60	45	45	20	15	15	---	---	---

* Data taken from Reference [16]

** Grain is not considered because there is no evidence to indicate that grain in the UK is grown, milled and consumed on a very local scale; Cow milk products are not considered, as it is considered unlikely that individuals will produce milk products themselves and consume them in significant quantities, Reference [11].

The breathing rates in the short-term assessment are presented for periods of a few hours. Two scenarios for adult breathing rate are considered including the average over the working day for light work and the average over the working day for heavy work. The adult breathing rate for the average over the working day for heavy work is selected in this document as the conservative value.

Indoor occupancy data is used where more survey information is available and more conservative assumptions are required. This data is age dependent, with appropriate values of 50% for adults, 80% for children and 90% for infants, Reference [15].

Doses to people indoors will be significantly lower owing to shielding provided by building structures. The 0.2 cloud gamma value for general assessments is considered typical for EU countries. The location factor for external irradiation from electrons (cloud beta) is set as 1 because the exposure is only from activity in the immediate vicinity and the activity concentration in air is considered to be the same indoors and outdoors. The gamma dose rate indoors from deposited activity is assumed to be reduced by a factor of 0.1, Reference [10].

T-2.4-3 Habit Data of Local Resident Family in Reference [6]

	Values Used in Stage 1&2&3 Assessment			Values Used in Short Term Assessment [∞]		
	Adult	Child	Infant	Adult	Child	Infant
Breathing rates (m³/h)	0.92	0.64	0.22	1.69	0.87	0.31
Occupancy at habitation (h/y)	8760	8760	8760	8760	8760	8760
Fraction of time spent indoors	0.5	0.8	0.9	0.5	0.8	0.9
Location factor cloud gamma *	0.2	0.2	0.2	0.2	0.2	0.2
Location factor cloud beta *	1	1	1	1	1	1
Indoor dose reduction factor for inhalation *	1	1	1	1	1	1
Shielding factor from deposited radionuclides *	0.1	0.1	0.1	0.1	0.1	0.1

* Data taken from Reference [10]

[∞] Date taken from Reference [17]

The direct radiation from the source on the site is included within the annual dose assessment. The layout of the UK HPR1000 is not determined at present, so the distance of direct radiation from the buildings which contain radioactive substances to the members of the public who spends 100% of their time at that location is assumed as 100 m to ensure the dose assessment is conservative. The habit data used for direct radiation assessment, Reference [9], is presented in T-2.4-4.

T-2.4-4 Habit Data Used for Direct Radiation Assessment

Parameter	Proposed Value		
	Adult	Child	Infant
Occupancy(h/y)	8760	8760	8760
Location factor for being indoors	0.1	0.1	0.1
Location factor for being outdoors	1	1	1
Fraction of time spent indoors	0.5	0.8	0.9
Fraction of time spent outdoors	0.5	0.2	0.1

2.4.4 Aquatic Ecosystem

An assumption is made that the site is coastal in nature and the liquid radioactive discharges will be made to a marine or estuarine environment.

Local compartment data has been selected that reflects the conditions adjacent to the Bradwell site (the proposed site for the UK HPR1000). A summary of the proposed parameters for the UK HPR1000 local compartment is provided in T-2.4-5. The low level of dispersion means that the resulting dose assessment is conservative.

T-2.4-5 Local Compartment Data Used in Fisherman Family Assessment in Reference [6] and [10]

Parameter	Stage 1	Stage2	Stage 3
Volume (m ³)	1.0×10^8	1.0×10^8	2.0×10^8
Depth (m)	10	10	10
Coastline length (km)	10	10	10
Volumetric exchange rate (m ³ /y)	3.2×10^9	4.1×10^9	4.0×10^9
Suspended sediment load (t/m ³)	1.0×10^{-5}	1.0×10^{-5}	2.0×10^{-4}
Sedimentation rate (t/m ² /y)	4.9×10^{-3}	4.9×10^{-3}	1.0×10^{-4}
Density of dry sediment particles (t/m ³)	2.6	2.6	2.6
Bioturbation rate (coastal water) (m ² /y)	3.6×10^{-5}	3.6×10^{-5}	3.6×10^{-5}
Diffusion rate (sediment diffusion coefficient) (m ² /y)	3.15×10^{-2}	3.15×10^{-2}	3.15×10^{-2}

2.4.4.1 Habit Data for Liquid Discharges

The fisherman family receive doses from:

- External irradiation from radionuclides deposited in shore sediments;
- The consumption of seafood incorporating radionuclides released from nuclear power plant.

The relevant exposure pathways are taken from habit data presented in T-2.4-6 to T-2.4-8. The generic intake rates presented are based on ingestion data in the UK, Reference [15]. The generic data in Reference [15] (which are recommended to be used when there is no site specific data), is deemed to be conservative and has been used broadly in previous GDAs. For the Stage 3 assessment, the habit data of Bradwell B in Reference [18] is considered mainly because that they are more conservative than generic data, which is listed in T-2.4-7 and T-2.4-8. It can make ensure the dose to members of public assessed at GDA stage that cannot be underestimated.

T-2.4-6 Habit Data for Fisherman Family (High Level Data for Stage 1&2
Assessment) in Reference [6]

	Adult	Child	Infant	Fraction in compartment	
				Local	Regional
Food Consumption Rates (kg/y)					
Fish	100	20	5	0.5	0.5
Crustaceans	20	5	0	1	0
Molluscs	20	5	0	1	0
Seaweed	0	0	0	1	0
Occupancy on Beach (h/y)	2000	300	30	1	0
Time Spend Handling Fishing Equipment (h/y)	2000	---	---	1	0

T-2.4-7 Habit Data for Fisherman Family (High Level Data for Stage 3 Assessment)
in Reference [6]

	Adult	Child	Infant	Fraction in compartment	
				Local	Regional
Food Consumption Rates (kg/y)					
Fish	100	29.5*	5	0.5	0.5
Crustaceans	20	5	0	1	0
Molluscs	20	5	0	1	0
Seaweed	0.7*	0.6*	0	1	0
Occupancy on Beach (h/y)	7424*	300	849*	1	0
Time Spend Handling Fishing Equipment (h/y)	2151*	144*	0	1	0

* These values come from the habits survey report of Bradwell in 2015 referring to Reference [18].

T-2.4-8 Habit Data for Fisherman Family (Average Level Data for Stage 3 Assessment)
in Reference [6]

	Adult	Child	Infant	Fraction in compartment	
				Local	Regional
Food Consumption Rates (kg/y)					
Fish	21.2*	29.5*	3.5	0.5	0.5
Crustaceans	1.75	1.25	0	1	0
Molluscs	5*	1.25	0	1	0
Seaweed	0.5*	0.6*	0	1	0
Occupancy on Beach (h/y)	5138*	300	849*	1	0
Time Spend Handling Fishing Equipment (h/y)	2000	144*	---	1	0

* These values come from the habits survey report of Bradwell in 2015 referring to Reference [18].

2.4.5 Human Population

The EA's initial radiological assessment methodology, Reference [8] and [9], is based on exposure pathways and groups which are likely to be the most adversely affected for a particular discharge route. The receptors for humans have been taken from the EA's *Initial Radiological Assessment Methodology* (IRA), Reference [8]. For the IRA, it is assumed that the most exposed groups include:

- a) Local resident family;
- b) Fisherman family.

The local population distribution is not required for radiological dose assessment at this stage (site-specific data will be used to inform a dose assessment once a suitable site has been selected). It is necessary to have some information on the region of the UK and larger range, to be able to calculate population (collective) doses. The UK, EU and world populations are used for collective dose assessment in PC-CREAM 08, Reference [10]. EU12 and EU25 are defined including twelve countries and twenty-five countries of EU respectively.

T-2.4-9 Population Data Used in Collective Dose Assessment

Country/Region	Population
UK	5.96×10^7
EU12	3.60×10^8
EU25	4.56×10^8
World	1.00×10^{10}

2.4.6 Sensitive Areas and Species

For the GDA, designated sites, sensitive habitats and protected species are only defined in a general sense in order to characterise the potential ecological receptors that may be present at a generic coastal or estuarine site.

European designated sites include Ramsar Sites, Special Protection Areas and Special Areas for Conservation. Nationally Designated Sites mainly include Sites of Special Scientific Interest and National Nature Reserves. Information on designated sites will be detailed at the appropriate time, i.e. at the site-specific permitting stage.

The considered reference organisms used in the NHB assessment are presented in T-2.4-10, Reference [12]. The reference organisms used are those presented as the reference organisms in the ERICA tool. The latest version of the Ar-Kr-Xe tool used to determine the impact of noble gas release in the terrestrial environment contains the same list of reference organisms as the ERICA tool. The reference organisms listed in the ERICA model are selected from four terrestrial and three aquatic ecosystems, which are typical for Europe. The use of these reference organisms is therefore considered to be appropriate for the assessment of the effects to NHB of the UK HPR100 at the GDA stage.

T-2.4-10 Reference Organisms Used in the Dose Assessment for NHB

Marine Reference Organisms	Terrestrial Reference Organisms
Benthic fish	Amphibian
Bird	Annelid
Crustacean	Arthropod – detritivorous
Macroalgae	Bird
Mammal	Flying insect
Mollusc - bivalve	Grasses and herbs
Pelagic fish	Lichen and bryophytes
Phytoplankton	Mammal – small burrowing
Polychaete worm	Mammal – large
Reptile	Mollusc – gastropod
Sea anemones/true corals	Reptile
Vascular plant	Shrub
Zooplankton	Tree

2.5 Conclusions

The data listed in this chapter meets an assessment requirement of the P&ID (item 1, Table 1), Reference [1]. This chapter describes the parameters which reflect the generic site characteristics (including meteorological data) to be used for the radiological and non-radiological environmental impact assessment of the UK HPR1000.

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At the site-specific environmental permit application stage, the specific characteristics of the site will be identified for the selected location for the UK HPR1000.

2.6 References

- [1] Environment Agency, Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, Version 3. October 2016.
- [2] General Nuclear System Limited, Pre-Construction Safety Report Chapter 1 Introduction, HPR/GDA/PCSR/0001, Revision 001, January 2020.
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