20 RADIOLOGICAL

20.1 RADIOLOGICAL IMPACTS ASSOCIATED WITH HINKLEY POINT

20.1.1 This Chapter of the Environmental Appraisal (EnvApp), examines the potential impacts and where required, mitigation of radiological discharges and radiation dose exposure during the construction and operational phases of the proposed development of two UK EPRs at Hinkley Point C (HPC) in Somerset.

20.1.2 The HPC site is adjacent to the existing Hinkley Point A (HPA) and Hinkley Point B (HPB) nuclear licensed sites and lies on the south side of Bridgwater Bay which forms part of the Bristol Channel. The Hinkley Point A and B sites are authorised to discharge liquid and gaseous radioactive waste into the environment under authorisations issued by the Environment Agency, so the combined impact of HPA, HPB and HPC requires assessment.

20.1.3 An assessment of the potential radiological impact of the development takes into account that radioactive contamination may already be present in the soil or groundwater on the Hinkley Point C site, which could result in the radiation exposure of members of the public or workers if mobilised during the construction phase of the proposed development.

20.1.4 During operation, radioactive waste will be produced by activities associated either directly or indirectly with operating and maintaining the Hinkley Point C reactors and ultimately from decommissioning the plant. As a result of all stages of operation of the site, during start-up, operation at power and shutdown for refuelling of each reactor, the HPC site will produce:

- liquid radioactive discharges;
- gaseous radioactive discharges; and
- solid radioactive waste (in the form of irradiated spent fuel and also other solid materials).

20.1.5 Liquid radioactive discharges are produced from effluents associated with systems for collecting and treating primary circuit water, fuel pool purification systems, operation of a radioactive laundry facility on site and washings from plant decontamination. After treatment to reduce the radioactive content of the effluent, it is sampled and monitored prior to final discharge to the sea in combination with water from the cooling water system. It is therefore subject to a considerable dilution before entering the sea.

20.1.6 Gaseous radioactive waste is produced from de-gassing the water in the primary circuit of each reactor, with the off-gas treated by processing systems to reduce the radioactive content. Gaseous waste is also produced from maintenance and operations in building areas containing loose radioactive contamination. These areas are serviced by ventilation systems which filter and reduce the radioactive content of the waste before discharge to atmosphere through dedicated stacks. Discharges from the stacks are continuously sampled and monitored.

20.1.7 The treatment of gaseous and liquid radioactive wastes and maintenance of radioactive plant and equipment produces solid radioactive waste. This includes spent ion exchange resins, spent filter media, worn-out components, contaminated protective clothing and tools, rags and waste oil. Irradiated spent fuel and solid radioactive wastes requiring interim storage prior to disposal will be stored in secure facilities on the Hinkley Point C site. This has the potential to
contribute to the radiation exposure of workers and members of the public in the immediate vicinity of the site.

20.1.8 The assessment of radiological impacts from the construction and operation of two UK EPRs at Hinkley Point C takes into account:

- the current radiological baseline of the site;
- the estimated radioactive discharges during operation;
- the estimated direct radiation exposure from the storage of spent fuel and radioactive waste, and the transport of radioactive materials to and from the site;
- appropriate risk assessment methodology and criteria;
- mitigation measures in place in the design of the UK EPR; and
- cumulative and collective impacts from the joint Hinkley site.

a) Scope of this Radiological Assessment

20.1.9 This Chapter summarises the current radiological baseline of the Hinkley Point C site, for ground water, surface water and soil. On the basis of site investigations carried out to date (Amec (2010) (Ref. 20.1), there is no evidence of anthropogenic (man-made) radioactive contamination being present on the proposed Hinkley Point C development site, and so the radiological risk to workers and members of the public during the construction phase can be regarded as negligible. Therefore, no requirement for a radiological assessment has been identified for the construction phase.

20.1.10 Potential radiological impacts on humans and non-human species as a result of liquid discharges to the Bristol Channel and gaseous discharges to the atmosphere during operation of the HPC site are described and assessed. This Chapter also contains an assessment of the annual dose to the most exposed members of the public from direct radiation exposure and an assessment of the radiological impact due to the transport of radioactive materials from the site.

20.1.11 The cumulative future impacts from the HPA, HPB and HPC sites are assessed. For HPA and HPB, the assessment is based on discharges at current authorised limits. The cumulative impacts estimated in this Chapter of the environmental appraisal assume that discharges from these facilities continue for the next 50 years and in parallel with those from the proposed HPC site. This is a conservative assumption, since within the next 50 years HPA is planned to be decommissioned into a quiescent state known as ‘care and maintenance’ and HPB is planned to be shut down, defuelled and decommissioned.

20.1.12 This assessment does not address radiological impacts during any associated decommissioning phases for HPC. These impacts will be addressed under a separate Environmental Impact Assessment (EIA) carried out under the specific legislative framework of the Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations 1999 (Ref. 20.2). Further information on decommissioning is available in Chapter 5.

20.1.13 This Chapter is not generally intended to duplicate information already available in other chapters of the environmental appraisal or in referenced documents:

- A more detailed assessment on the impact on human health from the operation of the proposed Hinkley Point C power station, including radiological impacts, is contained within the Health Impact Appraisal (HIA) (Ref. 20.3).
- Legislation and policy relating to radiation protection for the public, environment and workers is described in detail in the Nuclear Regulatory Context chapter (Chapter 4) and the Health Impact Appraisal (Ref. 20.3).
20.2 CURRENT RADIOLOGICAL BASELINE

a) Sources of Ionising Radiation Exposure in the United Kingdom

20.2.1 Radiation describes any process in which energy travels through a medium (other than by conduction) or through space. There are two broad classes of radiation: ionising radiation from sources such as radioactive materials or x-ray machines and which causes ionisation in material it interacts with and non-ionising radiation (such as radio waves or infrared and visible light) originating from other sources. For the purposes of this assessment, only ionising radiation is considered. Descriptions of ionising and non-ionising radiation and the potential health impacts of each type are provided in the Health Impact Appraisal (Ref. 20.3).

20.2.2 All individuals in the UK are exposed to ionising radiation to a varying degree from natural and anthropogenic sources. Natural sources include cosmic radiation from the sun and stars, gamma radiation from soil and rocks, internal exposure from naturally occurring radioactive material (such as potassium-40, or K-40) in food and within the body, and exposure to the radioactive gas radon. Anthropogenic sources include medical exposure to radiation (such as X-rays), occupational exposure for persons working with ionising radiation, fallout from the testing of nuclear weapons, exposure to products containing radioactivity (such as smoke detectors) and discharges from the nuclear industry.

20.2.3 The 2005 review of ionising radiation in the UK by the Health Protection Agency (Ref. 20.4) evaluated the magnitude of exposure of individuals in the UK to ionising radiation and this is reviewed in more detail in the Health Impact Appraisal (Ref. 20.3). The average radiation exposure for individuals in the UK has been stated to be 2,700 micro-sieverts (μSv) per year and the contribution from radioactive discharges from the nuclear industry is stated to be 0.9 μSv y⁻¹, i.e. less than 0.1% of total radiation exposure (Ref. 20.4).

20.2.4 The dose limit for members of the public in the UK is 1 mSv per year (Ref. 20.5). With the exception of medical exposures, no activity is permitted to give rise to discharges which would cause this limit to be exceeded. The dose limit applies to the sum of current and past licensed activities.

b) Existing Monitoring Data from around Hinkley Point

20.2.5 The Environment Agencies of the United Kingdom and Northern Ireland and the Foods Standards Agency have, since 1995, produced an annual Radioactivity in Food and the Environment (RIFE) report that records the results of radiological monitoring of food and environmental samples in the UK, especially near nuclear sites. The RIFE reports present a retrospective dose assessment based on the measured activity concentrations in various foodstuffs farmed or caught locally to nuclear sites and on local occupancy and habit data (such as the consumption of local foodstuffs).

20.2.6 Summaries of radioactive liquid and gaseous discharges made from existing sites in the Hinkley Point region and of measured concentrations of radioactivity in the environment around Hinkley Point are detailed in Chapter 6.
Point for the calendar year 2008 are provided in the Health Impact Appraisal (Ref. 20.3). The annual radiation dose to the most exposed person (also referred to as the critical group, or representative person) is reported in the RIFE report for 2008 (Ref. 20.7) to be 37 μSv y \(^{-1}\) for seafood consumers and 6 μSv y \(^{-1}\) for terrestrial foodstuff consumers. An assessed hypothetical total annual dose integrating across all pathways and including direct radiation from proximity to the existing HPA and HPB sites is reported to be 45 μSv per year (μSv y \(^{-1}\)). A portion of this dose is attributable to direct radiation.

20.2.7 The most recent RIFE reports (RIFE-8 to RIFE-13 inclusive) include an extensive list of nuclides and measurement types. The reports show that:

- the only nuclide consistently detected in drinking water and surface water is naturally occurring potassium-40;
- a consistent positive result for gross beta, considered to be the presence of the naturally occurring radionuclide K-40, is measured in seawater;
- mud and sediment taken from 1.6 km from the discharge pipeline, from Watchet and from Stolford shows consistent positive results for Cs-134 and Cs-137. The RIFE reports suggest that this represents the combined effect of releases from HPA and HPB, plus other nuclear establishments, along with historic contributions from Sellafield and fall-out from historical weapons testing and Chernobyl; and
- external gamma radiation dose rate measurements were barely above the limits of detection (for the survey equipment used).

20.2.8 From the review of the RIFE reports, monitoring of food and the environment in the vicinity of Hinkley Point indicates that current radiation doses to the most exposed members of the public from radioactive discharges and direct radiation shine are a small fraction of the 1 mSv y \(^{-1}\) public dose limit.

c) Surveys of the Hinkley Point C Proposed Development Site

20.2.9 Radiation and radioactive contamination surveys of the proposed development site at Hinkley Point have been performed on behalf of EDF Energy and are fully described in Amec (2010) (Ref. 20.1).

20.2.10 Values measured for anthropogenic radionuclides in sea water, ground water or surface water samples are very low, consistent with those reported elsewhere and would not present a hazard to human and non-human health or be of regulatory concern.

20.2.11 Soil monitoring surveys for radioactive contamination were carried out for the Built Development Area West in July and October 2008 and are in progress for the Built Development Area East. The concentration of radioactivity in soils was similar to background levels found throughout the UK, with Cs-137 radioactivity consistent with fallout from the Chernobyl accident in 1986. No samples were found to be “radioactive” as defined by the Environmental Permitting (England and Wales) Regulations 2010 (Ref. 20.8).

20.2.12 A walkover survey on the Built Development Area East and the Southern Construction Phase Area was completed in October 2009. The only enhanced readings above general background were in the north-east corner of the Built Development Area East, which is likely to have originated from a building on the Hinkley Point A site used to store radioactive waste.

20.2.13 Surveys of soil and ground water to date on the proposed development site at Hinkley Point C show that there is no evidence of anthropogenic radioactive contamination being present and so the radiological risk to workers and members of the public during the construction phase can be regarded as negligible.
20.3 POTENTIAL RADIOLOGICAL IMPACTS FROM HINKLEY POINT C

a) Introduction

20.3.1 The UK EPR is a pressurised water reactor similar to other units currently in operation worldwide (for example within the French nuclear fleet). Operation of the reactors and maintenance on the site in radiologically controlled areas will generate radioactive waste, either in liquid, gaseous or solid form. Additionally, storage buildings containing radioactive materials on site have the potential to enhance the radiation background local to the site.

20.3.2 More details on the operation of Hinkley Point C can be found in Chapter 4 of this environmental appraisal and more details on the management of radioactive waste and spent fuel can be found in Chapter 6.

b) Radioactive Liquid Waste Discharges

20.3.3 As noted in Section 1, liquid radioactive waste requiring eventual discharge from the site is produced from effluents associated with systems for collecting and treating primary circuit water, fuel pool purification systems, operation of radioactive laundry facilities and washings from plant decontamination.

20.3.4 Radioactive liquids on the Hinkley Point C site will be collected in engineered systems, preventing leakage and ensuring segregation of different liquid waste streams. Particular types of liquid waste will be recycled, where practicable, whilst other waste streams will be processed in a Waste Treatment Building (ETB). Liquid radioactive waste will be treated using ion exchange and filtration to reduce the radioactive content of the waste prior to storage in the holding and monitoring tanks.

20.3.5 Liquid radioactive waste in the holding and monitoring tanks will be discharged into the cooling water discharge system after sampling and monitoring. Each discharge will thus be subject to a considerable dilution with sea water before entering the sea. Table 20.1 below shows the estimated maximum annual radioactive content of liquid discharges from the operation of Hinkley Point C (Ref. 20.9) and these have been used in this assessment (Ref. 20.1).

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Annual liquid discharge rates GBq y⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-3</td>
<td>150,000</td>
</tr>
<tr>
<td>C-14</td>
<td>190</td>
</tr>
<tr>
<td>Ag-110m</td>
<td>1.14</td>
</tr>
<tr>
<td>Mn-54</td>
<td>0.54</td>
</tr>
<tr>
<td>Sb-124</td>
<td>0.98</td>
</tr>
<tr>
<td>Sb-125</td>
<td>1.630</td>
</tr>
<tr>
<td>Te-123m</td>
<td>0.52</td>
</tr>
<tr>
<td>I-131</td>
<td>0.1</td>
</tr>
</tbody>
</table>
20.3.6 Details of the production mechanisms for each of the specific nuclides (such as tritium and carbon-14) and groups of nuclides (such as Co-60 and Co-58, which are activation products, or Cs-137 and I-131, which are fission products) are given in the Chapter 6 of the Pre-Construction Environmental Report (PCER) (Ref. 20.9).

20.3.7 The discharge of radioactivity into the marine environment has the potential to cause a number of impacts, and these are assessed in this Chapter:

- Internal radiation exposure to a member of the public from the consumption of local foodstuffs containing radioactivity;
- Internal radiation exposure to a member of the public from the inhalation of sea spray containing radioactivity from discharges;
- External radiation exposure to a member of the public from radioactivity present in shoreline or estuary sediment; and
- Radiation exposure of non-human species.

c) Radioactive Gaseous Waste Discharges

20.3.8 As noted Section 1, gaseous radioactive waste is produced from de-gassing the water in the primary circuit of each reactor. Gaseous waste processing systems reduce the radioactive content of this ‘reactor off-gas’ using a combination of radioactive decay and adsorption ‘beds’, high efficiency filters and re-combination units.

20.3.9 Gaseous radioactive waste is also produced from maintenance and operations in building areas containing loose radioactive contamination. These areas are serviced by ventilation systems which filter and reduce the radioactive content of the waste before discharge to atmosphere through dedicated stacks. The particulate content of the waste is filtered using high efficiency filters, and charcoal adsorption filters can also be used to reduce the concentration of radioactive iodine in the discharge.

20.3.10 All gaseous discharges to atmosphere from each main discharge stack will be continuously sampled and monitored. The height of the stack for each UK EPR unit is optimised for the Hinkley Point site to ensure dispersal under all prevailing local weather conditions.

20.3.11 Discharges of radioactive gaseous effluent may be carried out from ‘minor routes’, such as the stack associated with an interim spent fuel store. The radioactive content of these discharges will be significantly lower than discharges from the main stacks and so ‘minor route’ discharges are not considered further in this assessment.

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Annual liquid discharge rates GBq y⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cr-51</td>
<td>0.12</td>
</tr>
<tr>
<td>Co-58</td>
<td>4.14</td>
</tr>
<tr>
<td>Co-60</td>
<td>6</td>
</tr>
<tr>
<td>Cs-134</td>
<td>1.12</td>
</tr>
<tr>
<td>Cs137</td>
<td>1.890</td>
</tr>
<tr>
<td>Ni-63</td>
<td>1.92</td>
</tr>
</tbody>
</table>
20.3.12 **Table 20.2** below shows the estimated maximum annual radioactive content of gaseous discharges from the operation of Hinkley Point C (Ref. 20.9) and these have been used in this assessment (Amec (2010) Ref. 20.1).

**Table 20.2: Maximum estimated activities expected in gaseous discharges from HPC (Ref. 20.9)**

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Annual gaseous discharge rates GBq y⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-3</td>
<td>6,000</td>
</tr>
<tr>
<td>C-14</td>
<td>1,400</td>
</tr>
<tr>
<td>Kr-85</td>
<td>6,260</td>
</tr>
<tr>
<td>Xe-133</td>
<td>28,400</td>
</tr>
<tr>
<td>Xe-135</td>
<td>8,920</td>
</tr>
<tr>
<td>Ar-41</td>
<td>1,306</td>
</tr>
<tr>
<td>Xe-131m</td>
<td>135</td>
</tr>
<tr>
<td>I-131</td>
<td>0.364</td>
</tr>
<tr>
<td>I-133</td>
<td>0.436</td>
</tr>
<tr>
<td>Co-58</td>
<td>0.0612</td>
</tr>
<tr>
<td>Co-60</td>
<td>0.0722</td>
</tr>
<tr>
<td>Cs-134</td>
<td>0.0562</td>
</tr>
<tr>
<td>Cs-137</td>
<td>0.0504</td>
</tr>
</tbody>
</table>

20.3.13 Details of the production mechanisms for each of the specific nuclides (such as tritium and carbon-14) and groups of nuclides are given in the **Chapter 6** of the Pre-Construction Environmental Report (PCER) (Ref. 20.9).

20.3.14 The discharge of radioactivity into the atmosphere has the potential to cause a number of impacts, and these are assessed in this Chapter:

- Internal radiation exposure to a member of the public from the consumption of local foodstuffs containing radioactivity;
- Internal radiation exposure to a member of the public from the inhalation of radioactivity in a gaseous discharge plume;
- External radiation exposure to a member of the public from radioactivity present in the terrestrial environment; and
- Radiation exposure of non-human species.
d) Sources of Direct Radiation Exposure

20.3.15 Direct exposure to radiation from the reactor buildings for members of the public will be negligible as the concrete shielding present will ensure contact radiation dose rates for the building are below limits of detection. Thus, direct radiation from the reactor buildings will not be measurable at the site boundary. However, exposure to direct radiation from radioactive waste stores will potentially contribute to public radiation exposure. In the UK, assessments of direct radiation are usually carried out by monitoring radiation levels at the site boundary and at the nearest habitation.

20.3.16 It will be necessary to transport radioactive materials to and from the Hinkley Point C site. These materials may include radioactive sources for non-destructive testing and examinations, fresh and spent nuclear fuel, radioactive equipment or plant components requiring off-site examination or maintenance, and radioactive waste. Members of the public may be exposed to direct radiation whilst the material is being transported. Although not included as part of the ‘direct radiation’ component for the purposes of assessing the impact on the most exposed person in the vicinity of Hinkley Point, this radiological impact still requires assessment against the relevant criteria.
20.4 IMPACT ASSESSMENT METHODOLOGY AND CRITERIA

a) Summary of Approach for the Assessment

20.4.1 The following sections describe the methodology adopted for assessing the actual and potential radiological impacts from the proposed HPC development.

20.4.2 European and UK legislation outlines the requirements for an Environmental Impact Assessment (EIA) and Environmental Statement to support planning for certain developments. This is described in detail in the Chapter on the legislative and planning policy context (Chapter 3).

20.4.3 There is currently no statutory defined method for carrying out EIA in the UK and in particular for assessing radiological impacts. General guidelines are available in, for example, the Department of the Communities and Local Government (Ref. 20.11), IEMA (2006) (Ref. 20.12) and the Environment Agency (Ref. 20.13). Using these guidelines, the approach adopted in this Chapter of the environmental appraisal is based on the following steps:

- Definition of the current baseline - for the radiological assessment of impacts from Hinkley Point C a current baseline has to be defined which confirms the current status of the environment on and around the site. This information has been provided in Section 2 of this report and in the Health Impact Appraisal (Ref. 20.3).

- Undertake the impact assessment - this covers the radiological impacts from the HPC site and assessment of these against recognised radiological protection standards for a specified range of human and non-human receptors. The method assumes maximum estimated discharges from two UK EPR reactors on the HPC site based on operating feedback from existing pressurised water reactors (PWR) of similar design and information provided in the Generic Design Assessment (GDA) PCER (Ref. 20.9). The discharges contain a specific range of radionuclides, the subsequent movement of which through the environment (air, water, soil) and into the food chain is predicted using a range of industry-standard computer models. Non-human species cover a generic range plus site specific ones based on ecological surveys of the site.

- Propose mitigation measures - this includes design and management controls which reduce the potential impact, and matches with the legal requirement to use ‘Best Available Techniques’ (BAT) to ensure the radiological impact of radioactive waste disposals is minimised and the legal requirement is met to reduce radiation doses to members of the public and workers to As Low As Reasonably Practicable (ALARP).

- Assess any residual impacts - undertaken following the implementation of any proposed mitigation measures.

b) Initial Radiological Assessment (IRA) - Impact on Humans

20.4.4 As noted in Amec (2010) (Ref. 20.1), the Environment Agency has provided a methodology for carrying out an Initial Radiological Assessment (IRA). This methodology document consists of two parts: (i) a user report containing an overview of the methodology and tables of “dose per...
unit release” (DPUR\textsuperscript{1}) for a large number of radionuclides; and (ii) a methods and input data report.

20.4.5 The purpose and scope of the initial assessment methodology is to provide a system for undertaking an initial cautious prospective assessment of the dose arising from sources of radioactive discharges to the environment and to identify those sources of discharges for which a more detailed assessment should be undertaken. The assessment consists of up to three stages:

- **Stage 1**: the Initial Radiological Assessment (IRA) is carried out using default data as defined in the IRA methodology. If the assessed dose is greater than 20 $\mu$Sv y\(^{-1}\) then a Stage 2 Assessment must be completed;

- **Stage 2**: the assessment uses refined data, as defined in the IRA methodology, which is more suited to the site in question. If assessed doses are greater than 20 $\mu$Sv y\(^{-1}\) then a Stage 3 Assessment must also be completed;

- **Stage 3**: this assessment is a separate site-specific assessment.

20.4.6 In the Initial Radiological Assessment the Environment Agency states that if direct radiation exposure of the public from sources on a site is known to occur, an assessment of direct radiation dose should be made. This is provided in the Health Impact Appraisal (Ref. 20.3), in Amec (2010) (Ref. 20.1) and is summarised in this Chapter. An assessment of the potential radiation exposure from the transport of radioactive material is also included, although it should be noted that this is not considered as part of the assessment of direct radiation ‘shine’ from the site.

20.4.7 In order to complete an assessment of dose to members of the public, it is necessary to determine which individuals would be most exposed to each of the sources of radioactivity by modelling potential discharges and environmental concentrations and making assumptions regarding the habits of individuals who may receive a radiation dose as a result of discharges to the environment. It is conventional to define a set of characteristics for a hypothetical group of people whose habits would result in their being the most exposed to any radioactive discharges from the site. The hypothetical group of people following these habits has been termed the ‘critical group’ or ‘representative person’. Within this assessment, the phrase ‘critical group’ is used.

20.4.8 As noted in Amec (2010) (Ref. 20.1), an initial range of ‘candidate critical groups’ has been identified, that covers individuals with habits (especially food consumption patterns) that might potentially result in them receiving the highest dose due to discharges and direct radiation (excluding transport). The subsequent assessments then allow those who are predicted to receive the highest dose (the critical group) to be identified.

\textsuperscript{1} In Calculating the DPURs, discharges are assumed to be continuous, uniform routine releases that continue for 50 years. Dose assessment calculations are carried out at the 50\textsuperscript{th} year. It is a modelling assumption that most radionuclides will reach equilibrium in the environment within 50 years.
20.4.9 Habitat data and food intake patterns for the Hinkley Point area that enable the calculation of ingestion dose are obtained from reports produced by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS). The survey used in this assessment covers was conducted around Hinkley Point in 2006 (Ref. 20.14). Calculation of where airborne and deposited radioactivity concentrations would be highest in the vicinity of Hinkley Point used data also from CEFAS reports.

20.4.10 The IRA for Hinkley Point C (Amec (2010) Ref. 20.1) identifies two local candidate critical groups for assessment. These are:

- Releases to Air - local resident farming family; and
- Releases to Coastal Water - fisherman family.

20.4.11 The criteria for assessment of the impact on humans are individual radiation dose exposures and collective radiation exposure (referred to as collective dose) over a defined population.

c) Individual dose assessment criteria

20.4.12 The criteria used for assessing the magnitude of radiological impacts on individual members of the public are based upon the constraints detailed in the HIA and these are summarised in Table 20.3. In the assessment section the estimated doses from the operation of the proposed HPC site are also compared against baseline doses resulting from natural background sources.

Table 20.3: UK dose limits, constraints and guidelines derived from International and European regulations and guidance

<table>
<thead>
<tr>
<th>Dose band</th>
<th>Source of the dose criterion used in the assessment</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 to 1.0 mSv y⁻¹</td>
<td>1.0 mSv y⁻¹ is the UK public dose limit. 0.5 mSv y⁻¹ is the site dose constraint.</td>
<td>‘Major’</td>
</tr>
<tr>
<td>0.15 to 0.5 mSv y⁻¹</td>
<td>0.5 mSv y⁻¹ is the site dose constraint. 0.15 mSv y⁻¹ follows the Health Protection Agency proposed advice concerning a dose constraint for members of the public for new nuclear power stations and waste disposal facilities.</td>
<td>‘Moderate’</td>
</tr>
<tr>
<td>0.02 to 0.15 mSv y⁻¹</td>
<td>0.15 mSv y⁻¹ (as above). 0.02 mSv y⁻¹ follows guidance issued to the Environment Agency for England &amp; Wales, below which regulators should not seek further reductions in public dose, provided the operator is using best available techniques to limit discharges.</td>
<td>‘Minor’</td>
</tr>
<tr>
<td>Less than 0.02 mSv y⁻¹</td>
<td>0.02 mSv y⁻¹ (as above).</td>
<td>‘Negligible’</td>
</tr>
</tbody>
</table>

20.4.13 As described in the HIA, advice regarding the use of the 10 μSv per year (0.01 mSv per year) criterion is relatively recent. Older documents and this assessment necessarily make a comparison to a 20 μSv per year criterion. In either case, Best Available Techniques continue to apply to the reduction of radioactive discharges and hence radiological impacts.
20 Radiological Impacts

d) Collective dose assessment criteria

20.4.14 As noted in Amec (2010) (Ref. 20.1), there is no legal dose limit on collective doses. However, the International Atomic Energy Agency (IAEA) has presented dose criteria which are considered sufficiently low that doses arising from sources or practices that meet these criteria may be exempted from regulatory control. This criterion is that the collective dose should be less than about 1 man Sv per year of discharge.

20.4.15 The concept of collective dose can be a useful tool in optimising the level of radiological protection. For instance, it can help to ensure a proper balance between individual and societal protection. Wherever practicable, doses should be distributed in a way which is equitable and a reduction in doses to members of the public may not be justified if it results in a very high individual dose to a worker, or group of workers.

20.4.16 The EA interim guidance document for the assessment of prospective public doses principles (Ref. 20.15) stated that discharges giving rise to per caput doses of less than a few nano-sieverts (nSv) per year of discharge can be regarded as trivial.

e) Radiological Impact Assessment - Impact on Non-human Species

20.4.17 Radiological impacts on non-human species, unlike those on humans, have no absolute regulatory or universal ‘value’. This is because different non-human species or their habitats have different perceived values depending on, for example, their rarity, sensitivity or location. After estimating the level of significance from the doses there is therefore a need to consider these aspects of the species or habitat affected and draw a final conclusion on the magnitude of the radiological impact and its significance. The methodology for undertaking this evaluation follows the generic methodology set out in Volume 1, Chapter 6 of the environmental appraisal.

20.4.18 The International Commission for Radiological Protection (ICRP) Publication 91 describes a framework for assessing the impact of ionising radiation on non-human species (Ref. 20.16). It sets out a systematic, risk-based approach to assessing radiological impacts on non-human species, reiterated in the ICRP 103 recommendations (Ref. 20.17).

20.4.19 There are no specific UK regulations for the protection of non-human species from radiation sources. However, UK regulations are in place to enforce the European Directives in the UK, the main one being The Conservation of Habitats and Species Regulations 2010 (formerly the Conservation (Natural Habitats &c. Regulations 1994 (Ref. 20.18). These implement the European Union (EU) Habitats Directive (1992) (Ref. 20.19) in the UK and require steps to maintain and restore to favourable conservation status the habitats and species of EU Community level interest.

20.4.20 In the GDA Process and Information Document (Ref. 20.20) the EA requires that an assessment of the likely impact of the radioactive discharges on non-human species is carried out. They refer to Environment Agency Research and Development Publication 128 (Ref. 20.21) and make recommendations for carrying out generic radiation dose assessments.

20.4.21 As noted in Amec (2010) (Ref. 20.1), the Environment Agency concluded that it is unlikely there will be any significant effects in populations from ionising radiation at the chronic dose rates listed below:

- $40 \mu\text{Gy h}^{-1}$ for terrestrial animal populations;
- $400 \mu\text{Gy h}^{-1}$ for terrestrial plant populations;
- $400 \mu\text{Gy h}^{-1}$ for populations of freshwater and coastal organisms; and
- $1,000 \mu\text{Gy h}^{-1}$ for populations of organisms in the deep ocean.
20.4.22 The computer modelling code ERICA (Ref. 20.22) and associated radiological effects database FREDERICA (Ref. 20.23) are assessment tools for predicting the dose and effects on non-human species from radioactivity in the environment. The ERICA default screening dose rate is 10 μGy h⁻¹. Therefore assessments falling below this screening level would cause no measurable harm to non-human species and so 10 μGy h⁻¹ can be regarded as the bounding dose assessment criteria.

20.4.23 The dose versus level of significance matrix in Table 20.4 has been developed (Ref. 20.1) for the assessment of radiological impacts on non-human species.

### Table 20.4: Significance criteria for non-human radiological impacts

<table>
<thead>
<tr>
<th>Dose band or constraint</th>
<th>Source of the dose criterion used in the assessment</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organism specific</td>
<td>Dose effects above the EA dose limits are organism specific. Refer to reports such as FREDERICA for predicted radiation effects</td>
<td>Major</td>
</tr>
<tr>
<td>Organism specific</td>
<td>As above, but effects less severe.</td>
<td>Moderate</td>
</tr>
<tr>
<td>1,000 μGy h⁻¹</td>
<td>Deep sea organisms Terrestrial plant, freshwater and coastal organism populations Terrestrial animal populations</td>
<td>Minor</td>
</tr>
<tr>
<td>400 μGy h⁻¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 μGy h⁻¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 μGy h⁻¹</td>
<td>ERICA screening dose rate</td>
<td>Negligible</td>
</tr>
</tbody>
</table>
20.5 RADIOLOGICAL IMPACT ASSESSMENT

a) Generic Design Assessment (GDA)

20.5.1 A Stage 1 assessment was undertaken as part of the Pre-Construction Environmental Assessment (Ref. 20.9), submitted for the Generic Design Assessment (GDA) carried out by the Health and Safety Executive (HSE) and the Environment Agency to assist the licensing process. This report is based on a single unit UK EPR. As noted in Amec (2010) (Ref. 20.1) and the HIA (Ref. 20.3):

- A Stage 1 assessment is intentionally highly conservative; and
- Estimated doses to the critical group exceeded 20 $\mu$Sv y$^{-1}$ and therefore a Stage 2 assessment was appropriate.

20.5.2 A Stage 2 assessment was completed for a single UK EPR unit as part of the PCER (Ref. 20.9). As noted in Amec (2010) (Ref. 20.1) and the HIA (Ref. 20.3):

- Conservative assumptions were made regarding an effective stack height and a local marine compartment volumetric exchange rate;
- All other assumptions and parameters remained unchanged from the Stage 1 assessment;
- It is appropriate for a Stage 2 assessment to sum the doses from all release routes to estimate a potential critical group dose; and
- Estimated doses to the critical group exceeded 20 $\mu$Sv y$^{-1}$ and therefore a Stage 3 assessment was appropriate.

20.5.3 A Stage 3 assessment was completed for a single UK EPR as part of the PCER (Ref. 20.9). As noted in Amec (2010) (Ref. 20.1) and the HIA:

- The 'site' was derived from the most conservative characteristics of the environment around existing UK nuclear sites, with respect to dispersion of liquid and gaseous discharges, habitation distances from sites and weather conditions;
- A standard assessment tool (PC-CREAM 98) (Ref. 20.24) was used to calculate individual doses from routine releases;
- Three scenarios (a ‘farming family’, a ‘fishing family’ and a ‘local resident’) were used in order to determine the most exposed members of the public (i.e. the critical group or representative person);
- Direct radiation doses were assessed to be negligible; and
- Estimated total doses to the critical group were 25.8 $\mu$Sv y$^{-1}$, exceeding 20 $\mu$Sv y$^{-1}$, and therefore a site-specific radiological impact assessment was appropriate.

b) Hinkley Point Site Specific Assessment for Impacts on Humans

i) Introduction to the Site Specific Assessment

20.5.4 Amec (Ref. 20.1) outlines a methodology for the assessment of the impact on the human population around Hinkley Point C. These methods were used to assess doses from HPA and HPB in order to determine the cumulative dose from the Hinkley Point Site, and the methods were consistent with the general methods developed for the GDA and were confirmed in the Health Impact Appraisal (Ref. 20.3) that they represented reasonable approaches and are based on widespread methods adopted within the UK. HPA and HPB and the proposed HPC are
assumed to discharge into the local marine compartment and the local terrestrial environment and give rise to exposures via the same exposure pathways.

20.5.5 Assessment methodologies were developed (Amec (2010) Ref. 20.1) to assess the impacts from a number of scenarios. These are for:

- The assessment of individual doses as a result of continuous releases of gaseous and liquid discharges to the environment;
- The assessment of direct radiation dose exposures;
- The assessment of radiation exposure from transport;
- The assessment of collective doses;
- The assessment of individual doses as a result of short-term releases to the environment;
- The assessment of individual doses as a result of build-up of radioactive materials in the environment; and
- Annual dose assessment of the critical group.

20.5.6 The assessments were based upon the predicted discharges to the environment, as summarised in Section 3 of this Chapter and site specific characteristics relating to the twin UK EPR units (discharge, dispersion and dose uptake pathways). Site characteristics assumed by Amec (Ref. 20.1) are also summarised in the HIA (Ref. 20.3).

c) The Assessment of Individual Doses from Continuous Releases

20.5.7 The two hypothetical resident human receptor groups (the ‘farming family’ and the ‘fishing family’) noted in the Stage 3 GDA assessment were used as the basis for determining the critical group from all HPC discharges.

20.5.8 Amec (Ref. 20.1) assumed that a farming family living near the coast could be exposed to gaseous discharges through the terrestrial pathways of:

- ingestion of contaminated foodstuffs (green vegetables, root vegetables, domestic fruit and wild/free fruits, dairy products and meat) grown or raised on the farm; and
- inhalation of, and external exposure to, the plume and deposited radionuclides.

20.5.9 The two foodstuffs contributing the highest fraction of dose were assumed to be consumed the ‘critical’ (maximum) rates in the appropriate CEFAS reports and all other foodstuffs were assumed to be consumed at average rates. This is known as the “Top Two” method. It ensures a realistically conservative estimate of ingestion dose and is consistent with the GDA study method and other studies of this nature.

20.5.10 It was also assumed the farming family could be exposed to marine discharges through the marine pathways of ingestion of locally sourced seafoods, external exposure to beach sediments and inhalation of sea spray when spending recreational time on a local beach. Average consumption rates of fish and shell fish and recreational activity times were taken from the CEFAS (Ref. 20.14) study to determine exposures. Overall, this critical group is therefore referred to as the ‘farming family with marine and gaseous exposure’. This combined exposure would make them potentially the most exposed persons from all HPC discharges.

20.5.11 Amec (Ref. 20.1) assumed that a fishing family could be exposed to liquid discharges through:

- contact with contaminated fishing gear and beach sediments;
- from ingestion of seafoods; and
- inhalation of seaspray.
20.5.12 This fishing family could live locally and would therefore be exposed to the same terrestrial pathways as the ‘farming family’. It was conservatively assumed that this family might live at the same location as the ‘farming family with marine and gaseous exposures’ and thus would also be exposed to the highest airborne and deposited activity concentrations from gaseous discharges from HPC. It was also assumed that they would consume locally grown produce at average rates. They are therefore referred to as the ‘fishing family with marine and gaseous exposure’ and they made up a second potentially most exposed group from all HPC discharges.

20.5.13 In each case, individual doses were calculated for 3 age groups: adult, 10 year old child and 1 year old infant. The calculated doses are presented in the section on critical group doses, below.

d) The Assessment of Direct Radiation Exposure from the Site

20.5.14 As described in Section 3 of this chapter and in Amec (2010) (Ref. 20.1) direct exposure to radiation (also referred to as radiation ‘shine’) from the reactor buildings for members of the public will be negligible, as the thickness of concrete shielding present in the building structures will ensure external contact dose rates are low and would be difficult to measure at the site boundary.

20.5.15 Direct radiation from the external walls of any radioactive Intermediate Level Waste (ILW) store or any Spent Fuel store will contribute to radiation exposure for a member of the public. In the UK, assessments of direct radiation are usually carried out by monitoring radiation levels at the site boundary and at the nearest habitation. Estimates of direct radiation exposure from HPA and HPB to local residents living within 1 km of the existing Hinkley Point Site, including contributions from discharges, were 4 μSv y⁻¹ in 2007 (Ref. 20.6).

20.5.16 Amec (2010) outlines the conservative assumptions made during the assessment of potential direct radiation dose from Hinkley Point C. A radiation dose rate appropriate for an ‘undesignated’ building was assumed to be at a distance of 1 metre from the outer wall of the building. For the purposes of this assessment, an ILW and a Spent Fuel building were assumed to be located at a distance of approximately 40 m from the coastal footpath that runs parallel to the northern boundary of the Hinkley Point Site. The dose rate at this location was calculated for several exposure scenarios:

- A reasonably conservative scenario where a person walks along the nearby coastal path over a distance of about 800 m daily, spending about 20 minutes walking past the site and would therefore receive a dose of 1.5 μSv y⁻¹;
- A more conservative scenario where a member of the public walking their dog for 2 hours per day remains stationary at a point opposite the point of highest potential exposure, with this ‘most exposed person’ predicted to receive an annual dose of 9.1 μSv y⁻¹;
- A local resident spending the whole year in close proximity to the HPC site, at a distance of ~1.3 km, but also taking into account the reduced dose rate while indoors (due to shielding effects of the walls of the dwelling), was calculated to receive an annual dose of 0.0014 μSv y⁻¹.

20.5.17 A summary of the doses from direct radiation from the proposed HPC site against the screening criteria for assessment of 20 μSv y⁻¹ is shown in Table 20.5 below:
Table 20.5: Direct radiation dose estimates

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Estimated dose μSv y⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal path - realistic</td>
<td>1.5</td>
</tr>
<tr>
<td>Coastal path - worst case</td>
<td>9.1</td>
</tr>
<tr>
<td>Closest dwelling - worst case</td>
<td>0.0014</td>
</tr>
</tbody>
</table>

20.5.18 The data in Table 5 shows that the impacts on these receptors are ‘negligible’, especially considering that the assumptions used in the assessment are conservative and actual doses are expected to be below those estimated.

20.5.19 The dose rate at the more distant location assumed for the ‘farming’ or ‘fishing’ families with marine and gaseous exposure from HPC discharges is estimated to be smaller than for the dwelling above and so need not be considered in assessing the dose from the HPC site to these two critical groups (Amec (2010) Ref. 20.1).

e) The Assessment of Direct Radiation Exposure from Transport

An assessment of the radiological consequences of the transport of radioactive materials to and from the proposed HPC site was carried out (Amec (2010) Ref. 20.1) and considered the transport of the following radioactive materials:

- Radiography sources (used for non-destructive testing of plant and equipment);
- Spent fuel assemblies;
- New uranium fuel assemblies; and
- Low level radioactive waste (LLW).

20.5.20 An assessment of radiation doses arising from spent fuel transport from the HPC site was included in the assessment (Amec (2010) Ref. 20.1), however this is a conservative assumption, since the interim storage of spent fuel is expected to be on the HPC site. The transport of ILW was excluded from the assessment, since interim storage is assumed to be on site.

20.5.21 The assumptions of the number of radioactive material consignments, the surface radiation doserates, the proximity to dwellings in the Hinkley Point area during transport are all described in Amec (2010) (Ref. 20.1). The highest annual dose received by a member of the public living adjacent to the Bridgwater railhead and exposed to spent fuel flasks was estimated to be 2 μSv y⁻¹. Members of the public standing at a bus stop could receive doses of up to 1.8 μSv y⁻¹ should they be exposed to all four material scenarios (NDT sources, spent fuel, new fuel, LLW). Members of the public living in a house close to a road have been conservatively estimated to receive doses of up to 1.67 μSv y⁻¹ from transports of new fuel.

20.5.22 Assuming that spent fuel will be stored on the HPC site, annual assessed doses would be reduced to a maximum of 1.67 μSv y⁻¹. The scenarios considered are conservative and are significantly lower than the applicable dose limit for members of the public of 1 mSv y⁻¹ from man-made sources in the Ionising Radiations Regulations 1999 (Ref. 20.5), which is applicable to transport operations. Furthermore, the doses are significantly below the screening criteria for detailed assessments of 20 μSv y⁻¹, so that doses to members of the public from the normal transport of radioactive materials to and from the HPC site can be regarded as ‘negligible’.
f) The Assessment of Collective Radiation Dose Exposure

20.5.23 Collective doses from gaseous and liquid discharges were calculated using the PC-CREAM (Ref. 20.24) modelling tool, using the HPA and HPB sites, population and agricultural product distribution within the European Community and the regional marine compartment into which the discharge is released, which are already built into the model. An effective stack height of 23.3 m for a 70 m stack was calculated (Ref. 20.1). Collective doses were truncated at 500 years as requested by the Environment Agency in the guidance (Ref. 20.15).

20.5.24 The population groups to be considered are the UK, Europe and the world. The population data for the UK, Europe and the world was assumed to be 55 million, 700 million and 10 billion respectively as these are the values used by PC-CREAM 98 (Ref. 20.24) to estimate collective doses.

20.5.25 Average individual doses (‘per caput’) for populations in the collective dose assessment were also calculated, allowing per caput doses to be compared with dose constraints. The collective and per caput doses to the UK, European and world populations from HPC gaseous and marine discharges are presented in Table 20.6 below.

<table>
<thead>
<tr>
<th>Collective dose (Man Sv)</th>
<th>Collective Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UK</td>
</tr>
<tr>
<td>Atmospheric</td>
<td>0.36</td>
</tr>
<tr>
<td>Liquid</td>
<td>0.021</td>
</tr>
<tr>
<td>Total Collective dose</td>
<td>0.38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average per caput dose (nSv)</th>
<th>Collective Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UK</td>
</tr>
<tr>
<td>Atmospheric</td>
<td>6.55</td>
</tr>
<tr>
<td>Marine</td>
<td>0.38</td>
</tr>
<tr>
<td>Total per caput dose</td>
<td>6.93</td>
</tr>
</tbody>
</table>

20.5.26 Total HPC discharges will result in per caput doses of less than 7 nSv to the UK population. The Health Protection Agency has stated that discharges giving rise to per caput doses of less than a few nano-sieverts per year of discharge can be regarded as trivial (Ref. 20.15). In such cases, the design is considered optimised.

20.5.27 The estimated collective doses can be considered as equivalent to the ‘negligible’ category of significance established in this chapter.

g) The Assessment of Individual Doses Resulting from Short-Term Discharges

20.5.28 Potential doses have been calculated for short-term gaseous discharges from a single EPR stack with separate calculations undertaken for the UK EPR Unit 1 and Unit 2 stacks for the same receptor location and assumed total discharge amounts and discharge rates (Ref. 20.1). Potential short-term doses, including via the food chain, were calculated for a local critical group based on the methods described in NRPB-W54 (Ref. 20.25). The doses were then compared with the assessment criteria.
20.5.29 The pathways of exposure and the exposure times which have been considered to assess the short-term impact are the following:

- Ingestion of foodstuffs (the associated dose is calculated in the year following the short-term release);
- Inhalation and external irradiation from the plume (the associated doses are calculated for the period of the passage of the plume);
- Ingestion doses were calculated using the ‘top two’ method described above; and
- External irradiation from deposited radionuclides (the associated dose is calculated for the year following the release).

20.5.30 The results for the assumed intake rate (Ref. 20.14) were 0.26, 0.23 and 0.45 μSv per discharge for adult, child and infant age groups respectively. For infants (the most exposed individual) the most significant exposure route is ingestion (97% of the dose received) followed by inhalation (2%). The most significant radionuclide is C-14 (95% of the dose received) followed by tritium (2%).

20.5.31 The predicted short-term dose is significantly less than the predicted dose due to the continuous release and therefore the calculations of doses to the critical group bound the radiological assessment for Hinkley Point C.

h) The Assessment of Individual Doses from the Build-up of Radionuclides

20.5.32 The Environment Agency has highlighted that at the end of the life of the power station, land may not be able to return to free and unrestricted use due to potential build-up of radionuclides. Build-up refers to the accumulation of radionuclides in environmental media due to discharges and accounts for the effects of gradual accumulation of radionuclides over the operating life of the plant. A range of potential groups can then be exposed to this source of radioactivity.

20.5.33 Potential activity concentrations in soil were assessed using calculated activity concentrations in air. Activity concentrations in seawater and on the local beach were also calculated (Ref. 20.1). The significance of the impact of the build-up of radioactivity will depend on the future use of the land and activities in the sea.

20.5.34 A methodology for estimating doses to members of the public from future use of land previously contaminated with radioactivity was used (Ref. 20.26). A review of potential uses of the sea was carried out based on uses discussed in the CEFAS study (Ref. CEFAS). Scenarios where occupancies are high and/or intakes of radionuclides occur will give the highest doses. Potential uses included:

- Water sports;
- Beach combing/walking;
- Hobby fishing (including consumption of catches);
- Commercial fishing, and
- Houseboat dwelling.

20.5.35 The results for the airborne concentrations and consequent concentration in soil at the off-site location with the highest concentration are described in Amec (2010) (Ref. 20.1).

20.5.36 The most restrictive scenario for which the build-up of discharges to the atmosphere has been assessed would be construction on potentially contaminated land (Ref. 20.1). It has been assumed that the most contaminated land off-site would be used for a future development and the total dose to a construction worker as a consequence of the future build-up of nuclides due
to the emissions from the HPC reactors has been calculated to be 0.0044 μSv y⁻¹. It should be noted that the predicted annual exposure to a future-use construction worker is based on the build-up of activity at the location of maximum predicted concentration outside the site boundary. The extent of this area of maximum concentration is relatively small and will reduce with distance from the site.

20.5.37 The dose to members of the public from future use of the sea has been assessed for the ‘fishing family’ group, but excluding the atmospheric contribution. The total dose to the ‘fishing family’ from marine discharges was calculated to be 1.08, 0.3 and 0.12 μSv y⁻¹ to adults, children and infants respectively.

20.5.38 Based upon the calculated doses, the radiological impact of the potential build-up of radionuclides from discharges from the proposed Hinkley Point C development can be regarded as ‘negligible’.

i) Summary of Critical Group Doses for Hinkley Point C

20.5.39 The ‘farming family with marine and gaseous exposure’ represents the critical group who may be exposed to gaseous discharges from the proposed HPC reactors and via marine pathways. As noted above and in Amec (2010) (Ref. 20.1), ingestion rates, inhalation rates and occupancy factors were assigned for members of the family. It was assumed that these individuals do not participate in fishing and therefore are not exposed through the handling of fishing gear exposure pathway.

20.5.40 The predicted doses to the ‘farming family with marine and gaseous exposure’ were calculated to be 2.7, 2.5 and 4.5 μSv y⁻¹ for adults, children and infants respectively. The dose of 4.5 μSv y⁻¹ is the highest dose estimated for discharges from the Hinkley Point C site.

20.5.41 The ‘fishing family with marine and gaseous exposure’ represents the critical group who may be exposed to radiation and radioactivity from discharges into the marine environment and via terrestrial pathways. The radiation exposure to the same three age groups as the ‘farming family with marine and gaseous exposure’ was determined, using assigned ingestion rates, inhalation rates and occupancy factors (Ref. 20.1). There are some foodstuffs (marine plants and algae) consumed by members of the public in the CEFAS survey (Ref. 20.14) which have not been included in the current assessment, because they are only consumed in small quantities by very few individuals.

20.5.42 The predicted doses to the ‘fishing family with marine and gaseous exposure’ were calculated to be 3.0, 2.3 and 3.6 μSv y⁻¹ for the adult, child and infant members respectively. The estimated doses are dominated by contributions from discharges of C-14 and tritium, and iodine-131 for the infant and children.

20.5.43 The highest doses due to discharges from HPC are those to infants in the ‘farming family with marine and gaseous exposure’. This is therefore the critical group for Hinkley Point C. The assessed dose of 4.5 μSv y⁻¹ can be regarded as a ‘negligible’ impact.

j) Hinkley Point Site Specific Assessment for Impacts on Non-human Species

20.5.44 As described in Amec (2010) (Ref. 20.1), to enable the assessment of the radiological impact on non-human species resulting from continuous discharges from HPC, four representative habitats were selected for the species they are likely to support in the vicinity of the proposed power station site:

- Habitat 1: lies adjacent to the Hinkley Point C boundary;
- Habitat 2: comprises the coastal mudflats and marine habitat of the adjacent estuary;
Habitat 3: lies within the Bridgwater Bay National Nature Reserve and includes both shoreline and a fringing terrestrial area; and

Habitat 4: comprises a small freshwater pond and lies within Habitat 1.

20.5.45 For the assessment of impacts upon marine biota from liquid radioactive discharges, by assessing the average activity concentration in a small area of sea around the discharge point the radiation exposure over a period of time for any biota present is more likely to be determined (Ref. 20.1). The local compartment defined for modelling Hinkley Point was used to determine concentrations in seawater and seabed sediments.

20.5.46 For the assessment of impacts from gaseous radioactive discharges, using meteorological data it was possible to calculate at specific bearings and distances from the HPC stacks the concentration in soil and air of gaseous discharged radionuclides.

20.5.47 The following conclusions can be drawn from the assessments (Amec (2010) Ref. 20.1):

- Habitat 1 is not a Special Site of Scientific Interest (SSSI), however, it is a habitat for bats and therefore special protection of the bats and their roosts must be considered. All of the estimated doses from HPC discharges are below the most stringent assessment level (10 μGy h⁻¹) described in Section 4. Therefore, the radiological impacts for non-human species in Habitat 1 from radioactive discharges from HPC are assessed as ‘negligible’;

- Habitat 2, as part of Bridgwater Bay, is a designated site and therefore of interest for regulatory purposes. All of the estimated doses from HPC discharges are below the most stringent assessment level (10 μGy h⁻¹) described in Section 4. Therefore, the radiological impacts for non-human species in Habitat 2 from HPC marine radioactive discharges are assessed as ‘negligible’;

- Habitat 3 has some sites and habitats within it that have specific designated status and therefore are of high importance to stakeholders. However, all estimated doses from HPC discharges are below the most stringent assessment level (10 μGy h⁻¹) meaning that there would be no measurable effects on these organisms as a result of radioactivity present from radioactive discharges. Therefore, the radiological impacts for non-human species in Habitat 3 from radioactive discharges from HPC are assessed as ‘negligible’; and

- Habitat 4 is not an SSSI or other designated site and all the estimated doses from the HPC discharges are below the most stringent assessment level (10 μGy h⁻¹). Therefore the radiological impacts for non-human species in Habitat 4 from radioactive discharges from HPC are assessed as ‘negligible’.

20.5.48 Overall, the radiological impact on non-human species for discharges from the proposed development at HPC has been assessed as ‘negligible’.
20.6 MITIGATION MEASURES FROM DESIGN AND OPERATION

a) Management of Radioactive Waste using Best Available Techniques

20.6.1 As part of the Generic Design Assessment (GDA) of candidate nuclear power plant designs in the UK, the Environment Agency has published a Process and Information Document (PID) (Ref. 20.20) for requesting parties to provide an evaluation of options considered in the design of their nuclear power plants. The analysis should include an evaluation of abatement options and show that the Best Available Techniques (BAT) will be used to minimise the production and discharge or disposal of waste.

20.6.2 As part of the GDA for the UK EPR, the use of BAT for abatement of discharges has already been discussed and further developed in Chapter 8 of the Pre-Construction Environmental Report (Ref. 20.10). Demonstrating the application of BAT remains an on-going consideration throughout the rest of the design, operational and eventually the decommissioning phases of the UK EPR.

20.6.3 The use, accumulation, storage, disposal and discharge of radioactive materials within England and Wales are regulated under permits issued by the Environment Agency (EA) under the Environmental Permitting (England and Wales) Regulations 2010 (Ref. 20.8).

20.6.4 Permits are only granted after a rigorous assessment process which includes the prospective assessment of the impacts on the public and non-human species. The prospective assessments are determined using modelling because it is not practicable to measure the exposure directly and it is essential that it can be shown that any doses received would be below regulatory guidelines and ‘As Low As Reasonably Practicable’ (ALARP).

20.6.5 ‘Best Available Techniques’ are the means an operator uses in the operation of a facility to deliver an optimised outcome, i.e. to ensure exposures are ALARP. The fundamental aim in the application of BAT is to prevent and, where that is not practicable, minimise waste generation and discharges to the environment.

20.6.6 There is no lower limit on doses below which the general requirement for optimisation does not apply. DECC and the Welsh Assembly Government (Ref. 20.28) have issued Statutory Guidance to the Environment Agency for England and Wales which includes the provision that, “where the prospective dose to the most exposed group of members of the public is below 10 μSv y⁻¹ from overall discharges... the Environment Agency should not seek to reduce further the discharge limits in place, provided that the holder of the authorisation applies and continues to apply BAT”.

20.6.7 A permit for the disposal of radioactive waste from the proposed new development at Hinkley Point C will be applied for separately from the planning application. The submission that supports the permit will need to demonstrate environmental optimisation of the design and management of the plant through the application of BAT. The permit requires the ‘environment case’ that supports the application of BAT to be maintained, reviewed and updated.

20.6.8 The fundamental design of the reactor circuit, the material composition of components in the reactor circuit that could produce radioactivity by neutron activation and the management arrangements for the control of reactor circuit chemistry will all minimise the production of radioactivity at source.
b) Overall Minimisation of Liquid Radioactive Discharges

20.6.9 The minimisation of radioactive isotopes in liquid discharges from the UK EPR and the reduction in overall radiological impact from the site centres on the design and management features, details of which are provided in the PCER (Ref. 20.10) but are also summarised below:

- Minimisation at source. This includes ensuring the leak-tightness of the fuel pins to minimise release of tritium and fission products such as iodine into the reactor coolant, and controlling the pH of the coolant to minimise corrosion effects that could give rise to activation products such as Co-60;
- Recycling and reuse of liquids (where practicable) in the reactor systems, to reduce the overall volume and activity of liquid requiring treatment and disposal;
- Partitioning of radionuclides (where practicable) for disposal in the manner which causes the least environmental impact;
- Optimisation of the dispersion of the cooling water by the design of the cooling water outfall, which will also aid the dispersion of any liquid radioactive discharges; and
- Treatment of discharges using combinations of filters, ion exchange resins and evaporators that remove activity from the effluents, concentrating and containing them into more compact and easily managed solid waste forms.

c) Overall Minimisation of Gaseous Radioactive Discharges

20.6.10 The minimisation of radioactivity in gaseous discharges from each UK EPR unit centres on the following design and management features. Further details are provided in the PCER (Ref. 20.10) but are also summarised below:

- Minimisation at source. The minimisation of gaseous activity at source relies on the same basic principles as for the liquids, especially maintaining the leak-tightness of the fuel pins since this is the main source of gaseous and volatile fission products in gaseous waste streams. Safety considerations are also taken into account in the application of BAT - for example, the nitrogen blanket is used in the chemical and volume control system increases the production and discharge of carbon-14 discharge from the site, but it is a much safer blanketing gas than hydrogen which has been used in other PWR designs;
- Recirculation and recycling of gases (where practicable);
- Partitioning of radionuclides (where practicable) for disposal in the manner which causes the least environmental impact;
- Optimisation of the dispersion of the gaseous effluent by the design of the discharge stacks; and
- Treatment of discharges using charcoal adsorption plant that permits radioactive decay of short half-life isotopes, and filters and catalytic recombination units that remove radioactivity from the effluents, concentrating and containing it into more compact and easily managed solid waste forms.

20.6.11 In the UK EPR, the design and operation of the heating, ventilation and air conditioning systems that extract air from potentially active areas throughout the plant follows a common approach based on currently accepted international methods used in all nuclear facilities. This minimises the risk of elevated radioactive gaseous discharges by ensuring all contaminated air is processed using the techniques noted above.
d) Mitigation for Specific Radioactive Isotopes

20.6.12 From the GDA assessments and from the assessments described in this chapter, it has been shown that doses to the most exposed members of the local population from the operation of Hinkley Point C from radioactive discharges are below the 20 μSv y⁻¹ criterion considered in the current assessment as ‘negligible’. However, the assessed doses are dominated by discharges of the radioactive isotopes carbon-14 (C-14) and tritium, so the mitigation measures for these are discussed in more detail below.

e) Carbon-14

20.6.13 C-14 in discharges from a PWR occurs in liquids and gases. In the latter it occurs in the form of carbon dioxide and also some methane. In the UK EPR, C-14 is minimised at source as far as possible by improved utilisation of the reactor fuel, which reduces the amounts of C-14 produced per unit of electrical energy produced. Some increased C-14 production in the UK EPR arises from the use of a nitrogen cover gas in one of the coolant processing tanks attached to the reactor circuit, the Volume Control Tank (VCT), but as noted above this has been implemented to avoid the more routine use of hydrogen that would otherwise present a flammability hazard in this part of the plant.

20.6.14 Within the various primary coolant and liquid waste processing systems, degasification of liquids assists in the partitioning of C-14 into the gaseous waste route and the majority of the C-14 is discharged in gases, with only a small proportion being in liquid or solid waste forms. Discharges of carbon-14 in gaseous form have a lower radiological impact than those discharged in liquid form.

20.6.15 As part of the overall design philosophy for the UK EPR, an extensive assessment of potential methods for the abatement of C-14 in liquids and gases has been carried out, including reference to IAEA Technical Report 421 (Ref. 20.27). None of these methods are currently used on operational power reactors and some are not technically feasible on a PWR.

20.6.16 Overall, the design of the EPR represents BAT with respect to discharges of C-14, and thus the potential radiological impact from discharges of C-14, provided levels of dissolved nitrogen in the primary coolant (the main avoidable source of this nuclide) are optimised.

f) Tritium

20.6.17 Tritium makes up the bulk of the total radioactivity discharged in liquids and is about 10% of the total activity discharged in gases from Hinkley Point C. However, it only makes a small contribution to the overall radiological impact due to discharges from Hinkley Point C. In liquid discharges from the UK EPR, the majority of the tritium is present as tritiated water and in gases it is present as tritiated water vapour.

20.6.18 In the UK EPR, tritium is minimised at source by a number of measures including the use of M5 fuel cladding which retains the bulk of the tritium formed by fission in the fuel, and the optimisation of boron and lithium concentrations. This includes the use of enriched boron and depleted lithium, combined with the use of burnable poisons in some fuel rods (including avoidance of boron and use of gadolinium) and reducing the beryllium content in the secondary neutron sources.

20.6.19 The recombination unit may help to ensure that tritium in the purge gas in the gaseous effluent treatment system is returned to and retained in the liquid phase, although to date this effect has not been quantified. The majority of tritium is discharged into the environment in liquid discharges. Discharge of tritium in liquid form has a lower radiological impact than the discharge of tritium in gaseous effluent.
20.6.20 As part of the overall design philosophy for the UK EPR, an extensive assessment of potential methods for the abatement of tritium in liquids and gases has been carried out, including reference to IAEA Technical Report 421 (Ref. 20.27).

20.6.21 The overall conclusion is that the containment and minimisation at source implemented in the UK EPR represents the BAT for this radioactive isotope. The final discharges of tritium have a low radiological impact and are a small fraction of the overall site radiological impact, which has been assessed as 'negligible'.

**g) Mitigation for Direct Radiation and Transport**

20.6.22 Doses from direct radiation ‘shine’ to members of the public from the storage of Intermediate Level Waste or spent fuel on the Hinkley Point C site have been assessed as ‘negligible’. Ensuring that these radiation exposures remain ALARP will be by:

- engineering controls, such as the design of the buildings to optimise the thickness of radiation shielding; and
- administrative controls, such as the routine monitoring of the externals of the building to verify that the external radiation doserate is suitable for the area around the building to be ‘undesignated’.

20.6.23 Estimated doses to members of the public from the transport of radioactive materials to and from the proposed HPC site are dominated by the transport of spent fuel. As noted in Section 5, this was based on the assumption in the assessment that the spent fuel would require movement off-site. Whilst this predicted annual dose is negligible (up to 2 μSv y⁻¹) doses will be mitigated by retaining an on-site spent fuel store, as is currently assumed in Chapter 6.
20.7 CUMULATIVE AND COLLECTIVE IMPACTS

a) Assessment of Cumulative Radiological Impact on Humans

20.7.1 The methodology used to determine the radiological impact resulting from discharges from HPA and HPB is described in Section 4. As noted in Section 1, for HPA and HPB the assessment is based on discharges at current authorised limits rather than actual discharge values, which is a conservative assumption. In addition, the estimates of cumulative impacts assume that discharges from these facilities continue for the next 50 years and in parallel with those from the proposed HPC site, which is also a conservative assumption, since within the next 50 years HPA is planned to be decommissioned into a quiescent state known as ‘care and maintenance’ and HPB is planned to be shut down, de-fuelled and decommissioned.

20.7.2 The discharges from HPA and HPB used for these assessments are presented in Table 20.7 and Table 20.8 below.

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Annual gaseous discharge limits (GBq y⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HPA</td>
</tr>
<tr>
<td>H-3</td>
<td>1,500</td>
</tr>
<tr>
<td>C-14</td>
<td>600</td>
</tr>
<tr>
<td>Ar-41</td>
<td>-</td>
</tr>
<tr>
<td>I-131</td>
<td>-</td>
</tr>
<tr>
<td>Co-60</td>
<td>-</td>
</tr>
<tr>
<td>S-35</td>
<td>-</td>
</tr>
<tr>
<td>Beta²</td>
<td>0.15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Annual liquid discharge limits (GBq y⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HPA</td>
</tr>
<tr>
<td>H-3³</td>
<td>1,800</td>
</tr>
<tr>
<td>Co-60</td>
<td>-</td>
</tr>
<tr>
<td>Cs-137</td>
<td>1,000</td>
</tr>
</tbody>
</table>

² Assumed to be Co-60 for HPA and HPB discharges
³ 0.025% of H-3 assumed to be discharged as Organically Bound Tritium (OBT)
### 20 Radiological Impacts

#### HINKLEY POINT C PRE-APPLICATION CONSULTATION – STAGE 2

**ENVIRONMENTAL APPRAISAL – VOLUME 2**

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Annual liquid discharge limits (GBq y⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-35</td>
<td>-</td>
</tr>
<tr>
<td>Other radionuclides⁴</td>
<td>700</td>
</tr>
</tbody>
</table>

#### b) Cumulative Effects on the Critical Groups from HPA, HPB and HPC from Discharges

20.7.3 The doses to the two critical groups of the farming and fishing families assumed to reside at the same locality and where maximum exposure to airborne and deposited activity from HPC gaseous discharges occurs, but due specifically to discharges from HPA and HPB, were estimated (Ref. 20.1). The methodology was the same as that used to estimate doses to these two critical groups due to discharges from HPC.

20.7.4 The cumulative doses to the ‘farming family with marine and gaseous exposure’ considered in the current assessments from liquid and gaseous discharges from HPA, HPB and HPC are given in Table 20.9. These cumulative doses conservatively assume all three reactor sites discharge at the authorised limits simultaneously. A breakdown of how these total cumulative doses are built up from those due to the discharges from HPA, HPB and HPC is provided in Amec (2010) (Ref. 20.1).

#### Table 20.9: Cumulative dose to the ‘farming family with marine and gaseous exposure’ exposed to liquid and gaseous discharges from Hinkley Points A, B and C

<table>
<thead>
<tr>
<th>Age group</th>
<th>Total predicted cumulative dose μSv y⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant</td>
<td>17</td>
</tr>
<tr>
<td>Child</td>
<td>7.3</td>
</tr>
<tr>
<td>Adult</td>
<td>6.8</td>
</tr>
</tbody>
</table>

20.7.5 Overall, infant members of this group receive the greatest dose and this is dominated from terrestrial sources (99% of the total). C-14 and S-35 dominate the total doses to all age groups and make up 34% and 49% respectively of the total dose to the infant, through the consumption of milk and milk products. The small dose contribution from the marine discharges due to the consumption of marine foods is dominated by C-14 and Organically Bound Tritium (OBT), making-up respectively 50% and 32% of the dose via this route. S-35 is only discharged from gas-cooled reactors, like the AGR at Hinkley Point B.

20.7.6 The cumulative dose from discharges from all three reactor sites to all age groups considered in the ‘farming family with marine and gaseous exposure’ critical group are lower than the total site dose constraint of 500 μSv y⁻¹ and are less than 20 μSv y⁻¹, so can be regarded as ‘negligible’.

⁴ Assumed to be Cs-134 for HPA and HPB
**d) Doses to the Fishing Family Critical Group**

20.7.7 The cumulative doses to the ‘fishing family with marine and gaseous exposure’ considered in the current assessments from liquid and gaseous discharges from HPA, HPB and HPC are given in Table 20.10. These cumulative doses conservatively assume all three reactor sites discharge at the authorised limits simultaneously. A breakdown of how these total cumulative doses are built up from those due to the discharges from HPA, HPB and HPC is provided in Amec (2010) (Ref. 20.1).

<table>
<thead>
<tr>
<th>Age group</th>
<th>Total predicted cumulative dose μSv y⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant</td>
<td>13</td>
</tr>
<tr>
<td>Child</td>
<td>6.5</td>
</tr>
<tr>
<td>Adult</td>
<td>7.8</td>
</tr>
</tbody>
</table>

20.7.8 Overall, the infant members of the ‘fishing family with marine and gaseous exposure’ receive the greatest dose from cumulative discharges. Although this is classed as a fishing family, the dose to all age groups is dominated by contributions from the terrestrial pathways which, in the case of the infant make up 98% of the cumulative dose received. C-14 and S-35 again dominate these cumulative doses to all age groups and make up 33% and 49% respectively of that to the infant age group, through the consumption of milk and milk products.

20.7.9 The cumulative dose from all three reactor sites to all ages in fishing family critical group are lower than the total site dose constraint of 500 μSv y⁻¹ and are less than 20 μSv y⁻¹, so can be regarded as ‘negligible’.

**e) Overall Impacts to the Critical Group from Discharges**

20.7.10 For both these critical groups, approximately half of the cumulative dose to adults and three-quarters of the cumulative dose to infants is due to the discharges from the HPB site, which is currently operating. These would therefore decrease significantly when the HPB site ceases operation, current scheduled to close in 2016 if no life extension is assumed. A much smaller fraction of the cumulative dose is due to discharges from the HPA decommissioning site.

20.7.11 HPC is estimated to contribute about 40% of the cumulative dose to an adult in the critical group and approximately 30% of the cumulative dose to an infant in the critical group. Doses to the critical groups from discharges from HPC are dominated by the radionuclide carbon-14 (Ref. 20.1). This is particularly relevant when considering the mitigation measures in Section 6.

20.7.12 In summary, the data shows that the HPA and HPB sites make the largest contribution to the cumulative doses to all age groups for both critical groups. However, the cumulative Hinkley Point Site doses for all age groups in both critical groups remain less than 20 μSv y⁻¹ dose and are thus assessed as of ‘negligible’ significance.

**f) Summated Dose from the Hinkley Point Site**

20.7.13 To allow comparison of the Hinkley Point site discharge doses with the dose limit, it is necessary to take into account historical and future discharges from HPA, HPB and HPC and future direct radiation from other facilities on the Hinkley Point site.
20.7.14 Retrospective critical group doses as a result of discharges from the existing Hinkley Point Site are assessed annually in the RIFE reports. The highest retrospective dose in recent years was 40 μSv to seafood consumers. This dose also includes a contribution from discharges from the GE Healthcare Cardiff site, which produces H-3 and C-14 for medical research.

20.7.15 Direct radiation dose from the existing HPA and B stations was measured to be 4 μSv y⁻¹ in 2007 in Table A4.1 of RIFE-13 (Ref. 20.6). This value is appropriate to use as the future direct radiation dose for the Hinkley Point Site as it was determined that the direct radiation dose at the closest dwelling to HPC would be 0.0014 μSv y⁻¹ and as HPA and HPB are decommissioned direct radiation doses from these facilities should reduce.

20.7.16 Summing the retrospective critical group dose (40 μSv to seafood consumers) with the direct radiation dose and the future exposures critical group dose (from 50 years of combined discharges from the Hinkley Point site) results in the summated dose for the site of 61 μSv. This is highly conservative and includes discharges not originating on the Hinkley Point site.

**g) Cumulative Collective Dose from Hinkley Point Site Discharges**

20.7.17 The collective doses to the UK, European and world populations due to gaseous and liquid discharges from the Hinkley Point Site are presented in Table 20.11 below.

| Table 20.11: Collective dose to the UK, European and world populations from Hinkley Point Site discharges |
|-------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Collective dose (Man Sv)                        | UK                              | Europe                          | World                           |
| Gaseous discharges                              | 1.9                             | 13.5                            | 100.3                           |
| Liquid discharges                               | 0.025                           | 0.23                            | 2.2                             |
| Total Collective dose                           | 1.9                             | 13.7                            | 102.5                           |

| Average per caput dose (nSv)                    | UK                              | Europe                          | World                           |
| Gaseous discharges                              | 34.5                            | 19.3                            | 10.0                            |
| Liquid discharges                               | 0.45                            | 0.33                            | 0.22                            |
| Total per caput dose                            | 34.5                            | 19.6                            | 10.3                            |

20.7.18 The collective dose due to liquid and gaseous discharges from the Hinkley Point Site is dominated by carbon-14, which accounts for 74, 92 and 100% of the dose to populations of the UK, Europe and the world respectively.

20.7.19 Per caput doses from all Hinkley Point Site discharges are in the nSv y⁻¹ range and thus in accordance with EA guidance (Ref. 20.15) the contribution to total doses to individuals will be insignificant. Therefore, collective and per caput doses from the Hinkley Point site have been assessed as ‘negligible’.
h) Build-Up due to Cumulative Discharges from the Hinkley Point Site

20.7.20 Calculated results for the soil concentration at the area off-site with the highest concentration at Year 60 due to all Hinkley Point gaseous discharges to the atmosphere and the activity concentration in the seawater and seabed sediment off the coast of Hinkley Point at Year 60 from all Hinkley Point Site marine discharges are presented in Amec (2010) (Ref. 20.1).

20.7.21 Following the methodology previously outlined in this chapter, the total dose to a construction worker as a consequence of the build-up of nuclides as a result of emissions from HPA, HPB and HPC has been calculated to be 0.018 $\mu$Sv y$^{-1}$.

20.7.22 The annual exposure due to the future use of the marine environment resulting from the cumulative discharges from HPA, HPB and HPC is likely to be associated with commercial fishing and leisure activities. Therefore the dose to members of the public from future use of the sea has been assessed as the ‘fishing family’ group (Ref. 20.1). The dose due to build-up to the ‘fishing family with marine and gaseous exposure’ from all marine discharges from the Hinkley Point Site was calculated to be 2.8, 0.67 and 0.24 $\mu$Sv y$^{-1}$ for adults, children and infants respectively (Ref. 20.1). This has been assessed as having ‘negligible’ significance.

i) Assessment of Cumulative Radiological Impact on Non-Human Species

20.7.23 The biota in the freshwater habitat most affected by discharges from the Hinkley Point Site cumulative discharges was calculated to be insect larvae, which would experience a dose of 2.97 $\mu$Gy h$^{-1}$ (Ref. 20.1). This is below the ERICA screening value of 10 $\mu$Gyh$^{-1}$ and well below the EA biota dose limits and can be regarded as ‘negligible’.
20.8 RESIDUAL IMPACTS

20.8.1 The UK EPR design has been developed using operational feedback from the wide experience of the EDF Group and AREVA NP. The UK EPR is designed to reduce the production of solid waste and liquid and gaseous radioactive discharges compared to previous reactor designs.

20.8.2 The following overarching goals were included in the design optimisation:

- Minimise the generation of radioactive wastes at source;
- Select the best materials of construction to minimise the generation and transfer or wastes, including the design of fuel;
- Reduction and control of tritium liquid discharges;
- Reduction and control of C-14 liquid discharges;
- Reduction of discharges of other radionuclides;
- Maximum recycling of boron (used in the primary circuit coolant);
- Optimisation of the primary circuit coolant quality (that can affect discharges); and
- Overall reduction of chemical discharges.

20.8.3 This chapter of the environmental appraisal has outlined the radiological assessments that have been undertaken for the impact associated with the construction and operation of the Hinkley Point C reactors and the overall site. The receptor groups, details and the overall outcomes of the assessment for the planned development are summarised in subsequent paragraphs.

20.8.4 The dose to the most exposed person from radioactive discharges from Hinkley Point C was calculated to be 4.5 $\mu$Sv y$^{-1}$, to infant members of the ‘farming family with marine and gaseous exposure’. This dose can be compared with the average dose to the UK population of 2,700 $\mu$Sv y$^{-1}$ from all sources of radioactivity (Ref. 20.4).

20.8.5 All individual doses from Hinkley Point C from continuous or short-term discharges and direct radiation are below the ‘negligible’ dose criterion of 20 $\mu$Sv y$^{-1}$, as given in the matrix developed for this assessment, and also below the Statutory Guidance dose constraint of 10 $\mu$Sv y$^{-1}$ below which progressive reductions in discharges will not be pursued as long as the application of BAT can be demonstrated.

20.8.6 Collective doses, resulting from HPC discharges, to populations of the UK, Europe and the world truncated at 500 years have been calculated (Amec (2010) Ref. 20.1). A more informative presentation of this data is in the form of per caput doses, which provide an estimate of the average dose to individual members of a given population. The ‘per caput’ dose from all discharges from Hinkley Point C to the UK population was calculated to be less than 7 nano-sieverts (nSv) y$^{-1}$. The Health Protection Agency has stated that discharges giving rise to per caput doses of less than a few nSv per year of discharge can be regarded as trivial.

20.8.7 The freshwater habitat represented the ‘worst-case’ estimated dose rates for non-human species. The species most affected was calculated to be insect larvae, which would experience a dose rate of less than 3 $\mu$Gy h$^{-1}$. This is below the default screening value of 10 $\mu$Gy h$^{-1}$ and well below the EA biota dose limits listed in Section 4.

20.8.8 The highest estimated annual dose to an individual (2 $\mu$Sv y$^{-1}$) due to transport of radioactive materials from Hinkley Point C is associated with the transport of spent fuel. This value can be compared to the dose limit for members of the public from the Ionising Radiations Regulations 1999 of 1,000 $\mu$Sv y$^{-1}$ which is applicable to transport operations. It should be noted that the
interim storage of spent fuel is proposed to be on the Hinkley Point C site so this estimated dose is conservative.

20.8.9 The assessments all show that, when judged against a range of stringent internationally agreed criteria on the Radiological Protection of Human and Non-human species, as summarised in the Health Impact Appraisal (Ref. 20.3), the assessed impacts from radioactive liquid and gaseous discharges from Hinkley Point C and other impacts due to site operations such as waste storage and transport are all considered negligible without additional mitigation being required over and above that already contained in the current design. Therefore, the residual impacts remain ‘negligible’.
REFERENCES


20.2 Statutory Instrument 1999 No. 2892, Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations 1999

20.3 Buroni, A., Health Impact Appraisal for Hinkley Point C Nuclear Power Station, 2010


20.5 Statutory Instrument 1999 No. 3232, The Ionising Radiations Regulations 1999


20.8 Statutory Instrument 2010 No. 675, The Environmental Permitting Regulations (England and Wales) 2010


20.10 UK EPR, Pre-construction Environmental Report. Chapter 8, Best Available Techniques, 2008

20.11 Department of the Communities and Local Government, Environmental Impact Assessment, 1999

20.12 IEMA, Guidelines for Environmental Impact Assessment, 2006 update


