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UK ABWR

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UK ABWR Generic Design Assessment

Summary of the Generic Environmental Permit Applications

Hitachi-GE Nuclear Energy, Ltd.

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1. Acronyms

ABWR	Advanced Boiling Water Reactor
ALARA	As Low As Reasonably Achievable
BAT	Best Available Technique
BBG	Backup Building Generator
BWR	Boiling Water Reactor
CAD	Controlled Area Drain System
C/B	Control Building
CD	Condensate Demineraliser System
CF	Condensate Filter System
COMAH	Control of Major Accident Hazards
CRD	Control Rod Drive (System)
CST	Condensate Storage Tank
CUW	Reactor Water Clean-up system
CW	Circulating Water System
DAC	Design Acceptance Confirmation
DAG	Diverse Additional Generator
DCD	Design Control Document
EA	Environment Agency
EAL	Environmental Assessment Level
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generator
EIA	Environmental Impact Assessment
EPR/EPR10	Environmental Permitting (England and Wales) Regulations 2010
F/D	Filter-Demineraliser
FAP	Forward Action Plan
FMCRD	Fine Motion Control Rod Drive
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
Gen. III+	Generation III+
GEP	Generic Environmental Permit
GSD	Generic Site Description
HAW	Higher Activity Waste
HCW	High Chemical impurities Waste System
HEPA	High Efficiency Particulate Air

Hitachi-GE	Hitachi-GE Nuclear Energy, Ltd.
HLW	High Level Waste
HPCF	High Pressure Core Flooder system
HVAC	Heating Ventilating and Air Conditioning system
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
IRAT	Initial Radiological Assessment Tool
IWS	Integrated Waste Strategy
J-ABWR	Japanese ABWR
LCW	Low Chemical impurities Waste System
LD	Laundry Drain System
LLW	Low Level Waste
LLWR	Low Level Waste Repository
LPFL	Low Pressure Core Flooder
LWMS	Liquid Waste Management System
MCR	Main Control Room
ME	Mechanical Engineering
MS	Main Steam system
NHS	Non-Human Species
NRW	Natural Resources Wales
NPP	Nuclear Power Plant
NSD	Non-radioactive Storm Drain
NSSS	Nuclear Steam Supply System
OG	Off-Gas System
ONR	Office for Nuclear Regulation
P&ID	Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs
PCSR	Pre-Construction Safety Report
PSR	Preliminary Safety Report
PWR	Presssurised Water Reactor
PWTF	Purified Water Treatment Facility
QMP	Quality Management Plan
R/B	Reactor Building
RCCV	Reinforced Concrete Containment Vessel
REP	Radioactive Substances Regulation – Environmental Principle
RHR	Residual Heat Removal system
RI	Regulatory Issue

RIP	Reactor Internal Pump
RO	Regulatory Observation
RPV	Reactor Pressure Vessel
RQ	Risk Quotient
RSR	Radioactive Substances Regulation
RSW	Reactor Building Service Water System
Rw/B	Radwaste Building
RWMA	Radioactive Waste Management Arrangements
S/B	Service Building
SF	Spent Fuel
SI	Structural Integrity
SJAE	Steam Jet Air Ejector
SoDA	Statement of Design Acceptability
S/P	Suppression Pool
SQEP	Suitably Qualified and Experienced Person
SWMS	Solid Waste Management System
SWSD	Storm Water Storm Drain
T/B	Turbine Building
TSW	Turbine Building Service Water System
ULSD	Ultra-Low Sulphur Diesel
VLLW	Very Low Level Waste

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3. Introduction

Hitachi-GE Nuclear Energy, Ltd. (Hitachi-GE) has developed a Generic Environmental Permit (GEP) application, for its Advanced Boiling Water Reactor (ABWR, hereafter referred to as UK ABWR) as part of the Generic Design Assessment (GDA) process. This process is overseen by the Office for Nuclear Regulation (ONR) and Environment Agency, with appropriate input from the environmental regulator in Wales - Natural Resources Wales (NRW)[1].

The GEP is the suite of documents developed by Hitachi-GE to provide the information requested within the 'Process and Information Document for the Generic Assessment of Candidate Nuclear Power Plant Designs' (P&ID) [Ref-1]. The P&ID is the Environment Agency guidance and process for assessing the suitability of new nuclear power station designs for England and Wales under the GDA process. The P&ID outlines the information required from the requesting party (which, in the case of the UK ABWR, is Hitachi-GE). Following a successful regulatory assessment of the GEP, the environmental assessment of the generic design would be complete and the requesting party would be issued a "Statement of Design Acceptability" (SoDA) for the UK ABWR by the Environment Agency and NRW. The SoDA may have associated "assessment findings" which would then need to be addressed at the site-specific permitting stage; these would not represent fundamental questions relating to the plant design, but typically cover areas where detailed design of more peripheral aspects have yet to be finalised.

NRW's role in the GDA process for the UK ABWR includes participating in:

- governance of the GDA process and technical oversight of the GEP programme.
- consultation and stakeholder engagement in Wales.
- the decision-making process, including the conclusions and advice arising from GDA work and the endorsement of the SoDA that would be issued if the UK ABWR is considered acceptable[2].

The Pre-Construction Safety Report (PCSR) [Ref-2] is a corresponding suite of documents developed by Hitachi-GE to address the design and safety information required by the ONR, as part of the process to obtain a Design Acceptance Confirmation (DAC) under the GDA process. The ONR's requirements for GDA are described within the 'New nuclear reactors: Guidance to requesting parties' document [Ref-3].

This GEP summary document introduces the UK ABWR design and describes the overall purpose and scope of the GEP submission (outlining the structure and layout of the reports). This document also addresses the requirements outlined in the P&ID to summarise key design, radiological dose and environmental impact information. In addition, information that is relevant in addressing the requirements of the P&ID and relevant to the GEP, though presented in other submitted GDA documents, is also highlighted.

This summary document complements the overall submission made to both the ONR and Environment Agency. In order to gain the fullest appreciation of the GEP submission for the UK ABWR, it should be read in conjunction with the remainder of the GDA reports and supporting documents.

[1] https://www.gov.uk/government/collections/assessing-new-nuclear-power-station-designs

[2] This would ensure that the environmental regulator in Wales (NRW) would be content that the conclusions arising from the SoDA could be carried through to any subsequent environmental permitting decisions which are the responsibility of NRW.

4. The GEP Application

4.1. Overview of the GEP Structure

The major components of Hitachi-GE's GEP submission, and the way they are structured, has been guided by the layout of the P&ID itself [Ref-1]; however, some adjustments to this structure have been made to aid the presentation of information and reflect the way information is held within Hitachi-GE.

Figure 4.1-1 shows how the P&ID requirements (shown in blue) are addressed through either the GEP core documents (shown in green), or PCSR chapters (shown in purple) and other GDA documents (shown in white). The numbering of the blue P&ID boxes maps to the numbered requirements included in Table 1 of the P&ID [Ref-1].

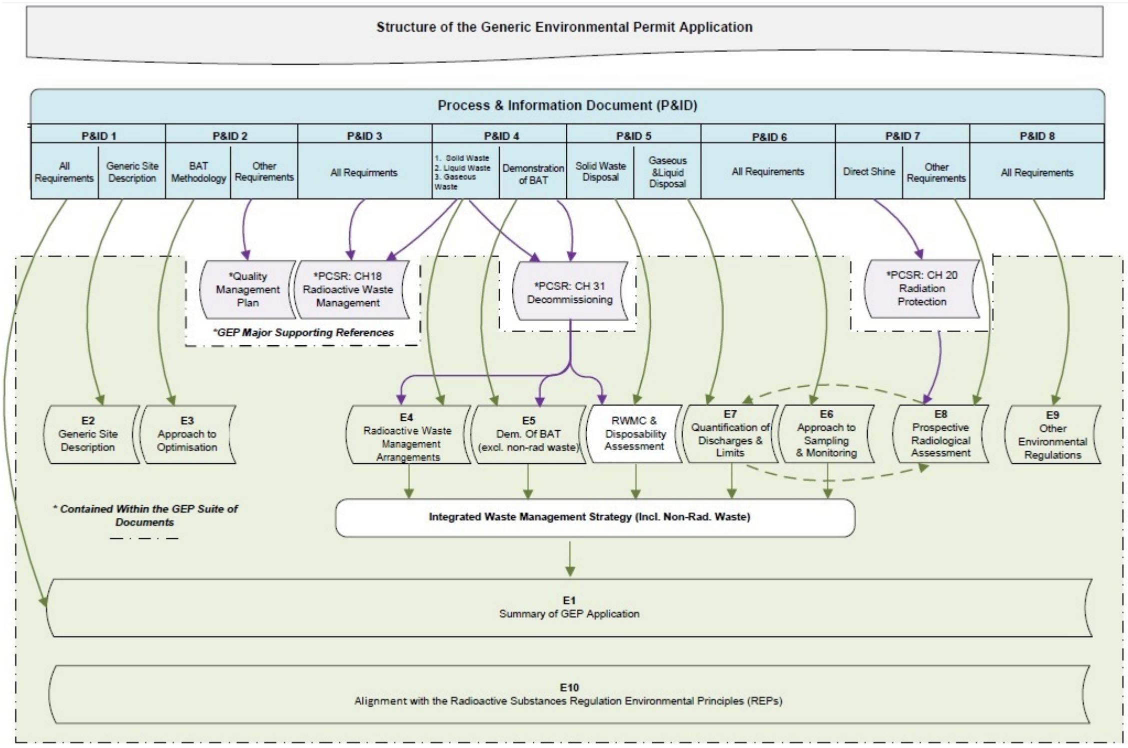


Figure 4.1-1: Structure of the GEP Application

Table 4.1-1 gives an overview of the contents of each core GEP document submitted by Hitachi-GE (documents E1 to E10 in pale green in Figure 4.1-1). Appendix A of this GEP summary document maps the P&ID requirements against the document structure laid out in Table 4.1-1, in order to clearly demonstrate how and where the Environment Agency's P&ID requirements have been addressed.

As shown in Figure 4.1-1, not all the information requested by the Environment Agency in the P&ID is presented in the core GEP documents. Some information requested as part of GDA is considered 'generic' to both the ONR and the Environment Agency's assessments and is presented in non-core GEP documents, for example:

- Information relating to the Hitachi-GE management systems is presented in Hitachi-GE's Quality Management Plan (QMP) for UK ABWR GDA [Ref-4]).
- Detailed descriptions of the radioactive waste management systems are presented in PCSR Chapter 18: Radioactive Waste Management [Ref-5].

In all such instances, there is referencing between documents to ensure clarity; Section 4.2 and Appendix A of this document provide further information.

Table 4.1-1: Summary of Hitachi-GE GEP Core Documents

GEP Number	Document ID/ Document Number	Document Name	Summary of document contents
E1	GA91-9901-0019-00001 XE-GD-0094	Summary of the Generic Environmental Permit Application (*this document*)	This GEP summary document introduces the UK ABWR design, describes the overall purpose and scope of the GEP submission (outlining the structure and layout of each report), and addresses the requirements outlined in P&ID to summarise key design, radiological dose and environmental impact information. This GEP summary document complements the overall submission made to both the ONR and Environment Agency, and should be read in conjunction with the remainder of the GDA reports and supporting documents in order to gain a full appreciation of the GEP submission for the UK ABWR.
E2	GA91-9901-0020-00001 XE-GD-0095	Generic Site Description	The Generic Site Description [Ref-6] describes the characteristics of the generic site which has been used in the assessments made in Hitachi-GE's GDA submission, including the initial radiological dose assessment which is part of the Prospective Dose Modelling [Ref-7]. A generic site is assumed because GDA is not a site-specific process. Where relevant, calculations and assessments made using the generic site will be re-visited in site-specific licensing. The majority of the site data used in the initial radiological assessment are from generic publications/guidance and are the same for any of the UK's potential coastal nuclear new build sites. In some instances, additional site-specific data has been used and this is described in the document.
E3	GA91-9901-0021-00001 XE-GD-0096	Approach to Optimisation	The GDA requirement to demonstrate the optimisation of radiological protection of the public and environment due to practices associated with the operation of the nuclear power station, i.e. to demonstrate the application of the Best Available Technique (BAT), is consistent with the conditions included in the Environment Agency's standard permit template and would apply to any future operator of a UK ABWR. The Claim Argument Evidence methodology used by Hitachi-GE in the GEP for the demonstration of BAT is presented in the Approach to Optimisation document [Ref-8]. This Claim Argument Evidence methodology is already widely used in the nuclear and other high hazard industries in the preparation of safety cases, including the PCSR of the UK ABWR. It is increasingly being adopted by projects across the nuclear industry for the demonstration of environmental compliance.

E4	GA91-9901-0022-00001 WE-GD-0001	Radioactive Waste Management Arrangements	The Radioactive Waste Management Arrangements (RWMA) document [Ref-9] describes the strategy for managing radioactive wastes and spent fuel across the UK ABWR's lifecycle (including decommissioning). The RWMA document has been produced with potential site operators in mind to ensure that any site-specific documents [i.e. a site-specific Integrated Waste Strategy (IWS)] can be developed from these generic arrangements without major changes/additions.
E5	GA91-9901-0023-00001 XE-GD-0097	Demonstration of BAT	The GDA requirement to demonstrate the optimisation of radiological protection of the public and environment due to practices associated with the operation of the nuclear power station, i.e. to demonstrate the application of the BAT, is consistent with the conditions included in the Environment Agency's standard permit template and would apply to any future operator of a UK ABWR. To ensure compatibility of the GEP application with all future site-specific permit applications Hitachi-GE has elected to structure the Demonstration of BAT document [Ref-10] using the BAT conditions contained within the standard Environmental Permit template. As requested in the P&ID, the Demonstration of BAT document presents the Claims, Arguments and Evidence which demonstrate the practice of generating electricity from the UK ABWR is optimised and that BAT is applied in: • Preventing and minimising (in terms of radioactivity) the creation of radioactive waste; • Minimising (in terms of radioactivity) discharges of gaseous and aqueous radioactive wastes; • Minimising the impact of those discharges on people, and adequately protecting other species; • Minimising (in terms of mass/volume) solid and non-aqueous liquid radioactive wastes and spent fuel; and, • Selecting optimal disposal routes (taking account of the waste hierarchy and the proximity principle) for those wastes.

E6	GA91-9901-0029-00001 3E-GD-K002	Approach to Sampling and Monitoring	A description of the sampling arrangements, techniques and systems for measurement and assessment of discharges of liquid and gaseous radioactive waste is presented in the Approach to Sampling and Monitoring document [Ref-11].
E7	GA91-9901-0025-00001 HE-GD-0004	Quantification of Discharges and Limits	In line with the requirements of the P&ID, a summary of the content of E7 [Ref-12] is provided in section 8.2.1 of this GEP summary document.
E8	GA91-9901-0026-00001 HE-GD-0005	Prospective Dose Modelling	In line with the requirements of the P&ID, a summary of the content of E8 [Ref-7] is provided in section 8.2.2 of this GEP summary document.
E9	GA91-9901-0027-00001 XE-GD-0098	Other Environmental Regulations	In line with the requirements of the P&ID, a summary of the content of E9 [Ref-13] is provided in section 8.3 of this GEP summary document.
E10	GA91-9901-0028-00001 XE-GD-0099	Alignment with the Radioactive Substances Regulation Environmental Principles (REPs)	The P&ID states that the Environment Agency's assessment of a requesting party's submission will be guided by the Radioactive Substances Regulation - Environmental Principles (REPs) [Ref-14]. The REPs are intended to form a consistent and standardised framework for the technical assessments and judgements that are made by the Environment Agency in relation to radioactive substances regulation, across permitting, compliance and enforcement. Although they are primarily written for use by the Environment Agency, certain REPs are referred to in the P&ID and as such act as references for Hitachi-GE to consider as part of the ongoing design process for the UK ABWR. The applicability of each REP to the UK ABWR GDA application has been assessed, and the Alignment with the REPs document [Ref-15] has been written to indicate how they have been considered in the UK ABWR GDA submission.

4.2. Links with Other GDA Documentation

4.2.1. Technical Description of Hitachi-GE Activities

The complete GDA submission made to the ONR and the Environment Agency represents the full technical description of Hitachi-GE activities and provides several important sources of fundamental information. Documents in the wider submission of particular relevance to the GEP include:

- Hitachi-GE UK ABWR Concept Design (C1a) [Ref-16];
- Genesis of ABWR Design (C2a) [Ref-17];
- Resilience of design against Fukushima type events (C3a) [Ref-18];
- ABWR General Description [Ref-19];
- US ABWR Design Control Documents (C5a) [Ref-20] (for information purposes only).

4.2.2. Links to the PCSR

There are several important sources of GEP-supporting information within the suite of safety-related documents being prepared as part of the UK ABWR GDA submission. The most important safety documents are the specific chapters of the PCSR listed below, with the key references used to support the GEP submission highlighted in bold:

- Chapter 9: General Description of the Unit (Facility) [Ref-21]
- Chapter 16: Auxiliary Systems (specifically sub-chapter 16.5) [Ref-22]
- **Chapter 18: Radioactive Waste Management** [Ref-5]
- Chapter 19: Fuel Storage and Handling [Ref-23]
- **Chapter 20: Radiation Protection** (specifically sub-chapter 20.7) [Ref-24]
- Chapter 23: Reactor Chemistry [Ref-25]
- Chapter 27: Human Factors [Ref-26]
- Chapter 28: ALARP Evaluation [Ref-27]
- Chapter 29: Commissioning [Ref-28]
- Chapter 30: Operation [Ref-29]
- **Chapter 31: Decommissioning** [Ref-30]
- Chapter 32: Spent Fuel Interim Storage [Ref-31]

The table of contents of the entire PCSR is shown in the Generic PCSR: Master Table of Contents [Ref-32].

4.2.3. Management Arrangements

The Hitachi-GE quality assurance arrangements for GDA have been developed to align with the expectations of both the P&ID and the GDA Interface Agreement [Ref-33] made between Hitachi-GE and both Regulators.

The location of the information requested in the P&ID regarding management arrangements (under item 2 of Table 1 [Ref-1]) is presented in this summary document in Appendix A. In summary, the quality assurance arrangements are found in Hitachi-GE's QMP [Ref-4] and its suite of supporting procedures which support all GDA activities.

The purpose of these quality assurance arrangements for GDA is to ensure:

- nuclear safety is the first priority;
- conformity to all applicable laws, codes, standards, regulations and UK Site Licence and Environmental Permitting Conditions, to fulfil regulatory expectations;
- coherent implementation of all activities undertaken during GDA which may affect quality, safety and environment; checking with regard to their effectiveness, as well as continual improvement; and,
- successful completion of the GDA process.

The QMP has been prepared in accordance with: ISO9001-2008 (Quality Management Systems); ISO 14001-2004 (Environmental Management Systems), for which Hitachi-GE has certification standards; and, International Atomic Energy Agency (IAEA) Safety Requirements No. GSR Part 2 [Ref-34].

The QMP [Ref-4] describes Hitachi-GE's management arrangements and provides references to where important elements of the arrangements are addressed in supporting procedures; examples include:

- Information on how the Hitachi-GE GDA project management team is arranged, the organisational structure and the associated roles and responsibilities.
- The development of the design and methods for controlling change to the design of the UK ABWR.
- The capability of the organisation by way of the assessment of competency of individuals, including key environmental roles, within the Hitachi-GE GDA organisation and of consultants supporting the organisation.
- Document control procedures, including document numbering and the methods used for formal communication within the GDA project and with the ONR/Environment Agency.
- The procedure by which management arrangements shall be subject to self-assessment, auditing and checking.

4.3. Status of the GEP

Figure 4.3-1 shows the indicative programme and activities (as described in the P&ID [Ref-1]) associated with the different steps of the development and assessment of the GEP as part of GDA process. This revision of this GEP summary document and the associated suite of GEP documents are submitted to the Environment Agency as part of GDA Step 3.

The ONR and EA GDA Step 3 and 4 programmes are different due to the public consultation requirement in the GEP programme, although both have the same overall completion date.

As the final PCSR (Rev. C) are issued at the end of August, GEP documents are updated for the consistency with PCSR.
Consultation (Step 4) has been successfully complete and now under post-consultation review to decide the issue of iSoDA or SoDA.

Approximate timeline for our GDA process

Timeline (months)	**Process element** (see key) 1	2	3	4	5 & 6	7 (if required)
-6 to 0						
0 to +6		♦a				
+6 to +24						
+24 to +27						
+27 to +36					♦b	
(+36 to +48)						♦c

Key

1 Initiation – preparation of submission
2 Initial assessment – begins with receipt of submission (a). Formal start of GDA
3 Detailed assessment
4 Consultation
5 & 6 Post-consultation review, decision and issue of iSoDA or SoDA (b). End of GDA if SoDA
7 Resolution of GDA issues and issue of final SoDA (c)

Figure 4.3-1: Indicative GDA Timeline [Ref-1]

5. The Requesting Party

Hitachi-GE was founded on 1st July, 2007 as a strategic global alliance between Hitachi, Ltd. and General Electric Co. Hitachi-GE offers nuclear power plant construction and maintenance services in partnership with its US counterpart GE-Hitachi Nuclear Energy. It is majority owned by Hitachi, Ltd. (80.01%), with General Electric Co. holding the minority stake (19.99%), and has its headquarters in Hitachi City, Ibaraki Prefecture, Japan.

Together, Hitachi Ltd. and General Electric Co. have experience in the nuclear sector reaching back over half a century; they have been co-operating on and contributing to the development and construction of Boiling Water Reactors (BWR) since 1967.

Since the introduction of BWR technology in the US in the 1960s, Hitachi, Ltd. has participated in the design, development and construction of over 20 BWR nuclear power plants within Japan. Together with all partners in the Hitachi group, Hitachi-GE has established a comprehensive line-up of nuclear power services including planning, design, manufacturing, installation and maintenance of nuclear power generation plants, as well as training for operators and continued research and development.

6. Overview of the Design

The BWR is one of the most common types of reactors operating in the world today, examples of which operate across the United States, Europe, Central America, India and Japan. The UK ABWR is the latest BWR design: a generation III+ (Gen. III+) reactor. The ABWR is the only Gen. III+ design to have reached commercial operation anywhere in the world, and is the world's most advanced operational reactor design.

The ABWR was developed in collaboration with various international partners and support from power companies with experience in operating BWR plants. The design is based on operational experience, utilising the tested and proven technology of previous BWR generations, with the aim of enhancing safety, operability and cost efficiency. This has been achieved through simplification in the design of reactor systems and containment that form the basis of the ABWR design.

Further safety enhancements have been made to achieve greater levels of nuclear safety against severe conditions. These enhancements focus on 'defence in depth' (i.e. having multiple numbers of back-up systems available) to address the Fukushima-daiichi nuclear power plant accident caused by the earthquake and subsequent tsunamis on 11th March 2011. These improvements focus on ensuring water and electricity supply to the site and the provision of more mobile emergency back-up equipment, as well as changes to site layouts.

There are four operating ABWRs within Japan and four more under construction worldwide, as shown in Table 6-1:

Table 6-1: Global ABWR Presence

Operating ABWR	ABWR under construction
Kashiwazaki-Kariwa Nuclear Power Plant (Japan) 6	Shimane Nuclear Power Plant (Japan)
Kashiwazaki-Kariwa Nuclear Power Plant (Japan) 7	Lungmen Nuclear Power Plant (Taiwan)
Hamaoka Nuclear Power Plant (Japan)	Higashidori Nuclear Power Plant (Japan)
Shika Nuclear Power Plant (Japan)	Ohma Nuclear Power Plant (Japan)

The fundamental design differences between all BWR designs and the other most common type of light water reactors, Pressurised Water Reactors (PWRs), are (i) in BWRs the bulk boiling of water occurs in the reactor core and not in a secondary system as it does in PWRs; and (ii) the steam produced from the boiling water in the BWR core is sent directly to the turbine used to turn the generator to produce electricity, i.e. there is a 'single loop' of circulating water and steam. These characteristics contribute to simplification in the design and systems required for both the operation and safety of the plant. Figure 6-1 shows a simplified outline of a UK ABWR to highlight these two points of difference from other common light water reactors.

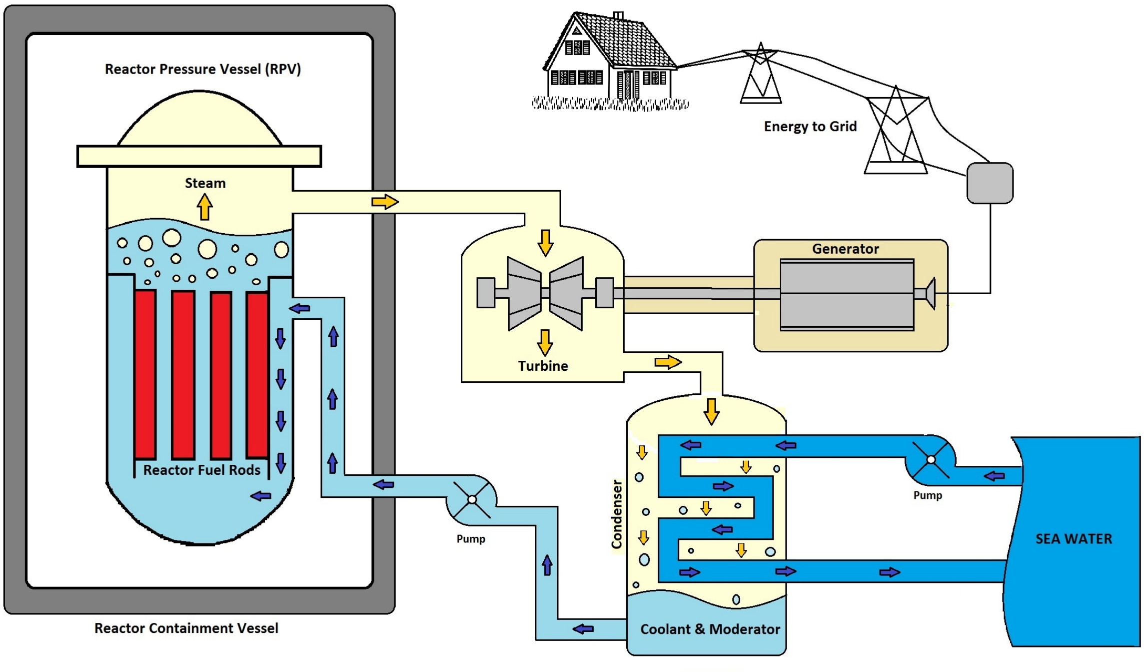


Figure 6-1: Simplified Outline of the UK ABWR Single-loop System

6.1. System Configuration of the UK ABWR

Figure 6.1-1 shows a schematic configuration and the main systems of the UK ABWR [Ref-19]. The main systems shown in the figure are:

- Reactor Pressure Vessel (RPV)
- Main Steam (MS) Piping
- Reinforced Concrete Containment Vessel (RCCV)
- Reactor Internal Pump (RIP)
- Fine Motion Control Rod Drive (FMCRD)
- Reactor Water Clean-Up System (CUW)
- High Pressure Core Flooder system (HPCF)
- Residual Heat Removal system (RHR)

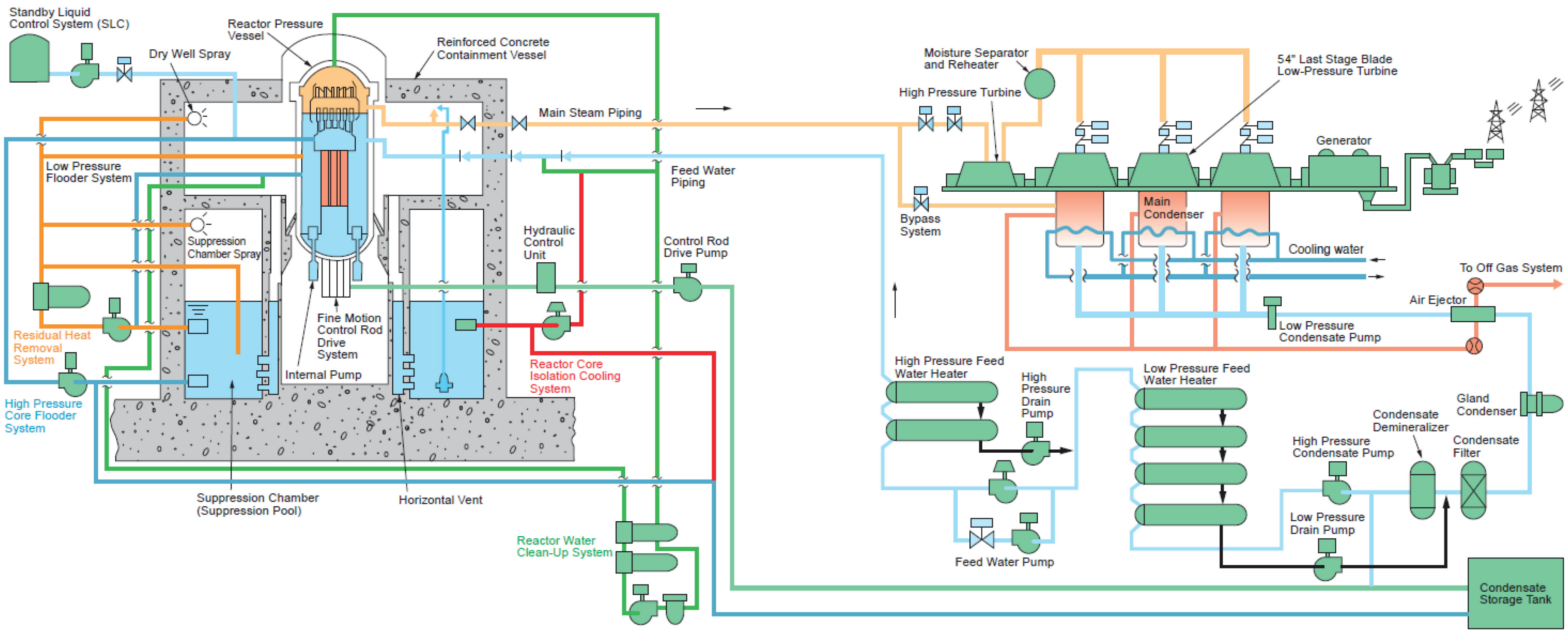


Figure 6.1-1: Schematic Configuration of the Main Systems of the UK ABWR

6.2. Main Design Features of the UK ABWR

As described at the start of section 6, the UK ABWR was designed with the aim of simplifying the design and improving operation of predecessor BWR plant, as well as enhancing the safety and reliability of structures, systems and components [Ref-19]. Simplification, safety and reliability enhancements have been a continuous effort since the initial introduction of the BWR technology in the 1960s and remain an ongoing focus today. Some of the major UK ABWR improvements and differences relative to previous BWR designs include:

- Enhanced safety and reliability;
- Improvement of capacity factor (i.e. ability to generate power);
- Reduction of the radiation dose to which workers are exposed; and,
- Improvements in operability.

Improvements such as those highlighted above enhance the environmental performance of the reactor as operations are made even more predictable, straightforward and safe. The main improvements applied to the systems and equipment of the UK ABWR are summarised as follows [Ref-19]:

Reactor Internal Pump (RIP)

UK ABWR RIPs are attached to the bottom of the RPV to directly circulate the flow of water (the coolant) inside the reactor. In previous BWR designs the coolant water is recirculated using a recirculation pump and pipework loop external to the RPV, in combination with a jet pump inside the RPV. With the RIPs inside the UK ABWR, there are no external pumps and pipework for the recirculation of reactor coolant water. The major environmental advantages are: improved control and containment of the reactor coolant water due to fewer RPV penetrations and pipework joints, and a reduction in solid waste at decommissioning from pump and pipework.

Fine Motion Control Rod Drive (FMCRD)

The FMCRD system of the UKABWR utilises two different power sources: an electric motor for normal operation; and, a conventional hydraulically-driven mechanism for emergency insertion. This diversification of power sources increases reliability and fine motor control during normal operation, thereby improving the safety and environmental performance of the fuel.

Reinforced Concrete Containment Vessel (RCCV)

The UK ABWR uses a smaller RCCV which is integrated with the Reactor Building (R/B), instead of the conventional steel containment vessel of its predecessors. The concrete part is pressure-resistant whilst the steel liner prevents leakage. A more compact RCCV also improves seismic resistance and increases cost efficiency and environmental performance through reduced construction and decommissioning materials.

Emergency Core Cooling System (ECCS)

The ECCS of the UK ABWR is composed of three electrically and mechanically independent divisions to ensure continued submergence of the core during a loss of coolant accident (LOCA). The three systems (High Pressure Core Flooder System (HPCF), the Reactor Core Isolation Cooling System (RCIC), and the Low Pressure Core Flooder System (LPFL)) are used under different fault scenarios.

New control panel in the Main Control Room (MCR)

This control panel is composed of the main control console and a wide display panel. Utilising a flat display, the main control console and large display panel integrate monitoring and operational functions based on feedback from operational experience. The integrated digital monitoring control system incorporates a high-level human interface and increased scope of automation. The sharing of information by the whole MCR team is facilitated through the wide display panel.

Turbine Equipment

The turbine equipment has been designed and manufactured to increase efficiency, reliability and to enhance plant performance. For example, the UK ABWR has longer turbine blades than those of previous BWR generations making them more efficient at generating electricity. Reliability improvements reduce the need for unplanned maintenance which in turn reduces radiological dose to workers and the generation of waste materials.

6.3. Key Specifications of the ABWR Nuclear Power Plant (NPP)

Table 6.3-1 shows the key specifications of the UK ABWR.

Table 6.3-1: Key Specifications of UK ABWR

	Item	Specification
Output	Plant Gross Electrical Output	Approx. 1,350 MWe
	Reactor Thermal Output	3, 926 MWt
Reactor rate pressure		Approx. 7.2 MPa (abs)
Reactor Core	Fuel Assemblies	872
	Control Rods	205
Reactor Equipment	Recirculation System	Internal pump method
	Control Rod Drive (CRD)	Hydraulic / electric motor drive method
Primary Containment		Reinforced Concrete Containment Vessel (RCCV)
Residual Heat Removal System		3 divisions
Turbine System	Turbine (final blade length)	Tandem-compound 6-flow exhaust condensing-type
	Moisture Separation Method	Reheat type

Source: [Ref-19]

7. Scope of Generic Design Assessment

The term ‘UK ABWR’ includes not only the reactor itself but also all buildings and connecting tunnels which are dedicated exclusively or primarily to housing systems and equipment related to the nuclear system, or which control access to those pieces of equipment and systems. There are five main buildings within the scope of the UK ABWR GDA:

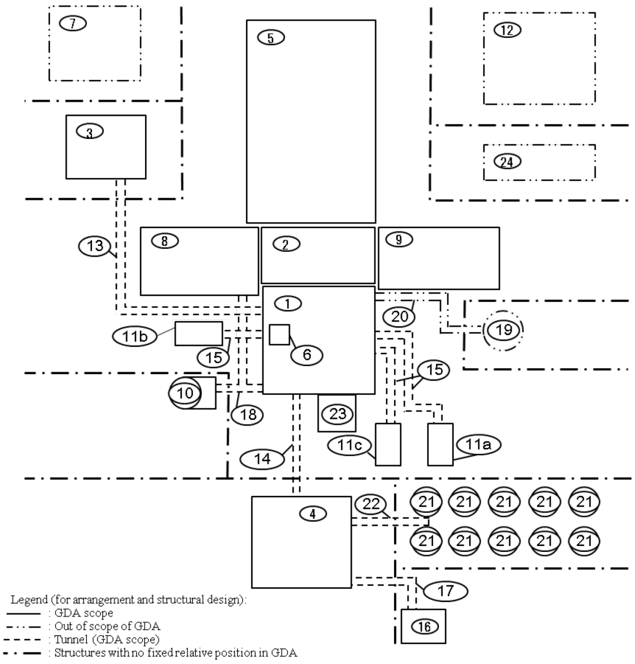
- Reactor Building (including containment);
- Turbine Building;
- Control Building;
- Radioactive waste (‘Radwaste’) Building; and,
- Service Building;

7.1. Plant Buildings and Discharge Points

As GDA is a generic assessment, a generic site layout is assumed – this layout may be subject to alteration in later site-specific permitting. The layout of the main buildings on the generic UK ABWR nuclear power station being considered in GDA is shown in Figure 7.1-1 (taken from [Ref-6][Ref-7]), along with a summary of each of their functions in the text that follows. A description of the main components and operation of the UK ABWR is provided in the GDA UK ABWR Concept Design [Ref-16].

Figure 7.1-1 shows a single discharge point to air for gaseous radioactive releases, located on the roof of the Reactor Building (no. 6: main stack). There is also a single outlet for radioactive releases to sea (not shown in Figure 7.1-1, see Figure 8.1-1 and Figure 8.1-2 for further details). There will be separate non-radioactive discharge points for gaseous discharges from combustion plant (diesel generators etc).

There may be additional radioactive discharge points from a number of “minor sources”, but these are not addressed at GDA stage. These minor sources include those from the LLW waste management facilities and the interim storage facilities for Intermediate Level Waste (ILW) and Spent Fuel (SF). These facilities are out of scope of the GDA as they will be designed at the site-specific stage to the specification of the future operator. Furthermore, although the footprint of the Service Building (S/B) is within the scope of GDA, the discharges of its building ventilation system (known as its Heating Ventilating and Air Conditioning System or HVAC) which are made via a separate vent in the S/B roof, are not addressed in GDA. This is because future operators will decide on the precise plant and equipment that the S/B will house. The impact on discharge limits and dose modelling for these minor sources will be fully accounted for at the site-specific permitting stage where relevant; however, it is expected that the discharges from these facilities will make up only a small fraction of the overall site radioactive discharges.



No.	FACILITY
1	REACTOR BUILDING (R/B)
2	CONTROL BUILDING (C/B)
3	HEAT EXCHANGER BUILDING (Hx/B)
4	BACKUP BUILDING (B/B)
5	TURBINE BUILDING (T/B)
6	MAIN STACK
7#	CIRCULATING WATER STRUCTURE (CW/S)
8	RADWASTE BUILDING (Rw/B)
9	SERVICE BUILDING (S/B)
10	CONDENSATE STORAGE TANK (CST) STRUCTURE
11	EMERGENCY DIESEL GENERATOR BUILDING (EDG/B)
12#	SPENT FUEL STORAGE FACILITY
13	RCW TUNNEL, 3 connected cells
14	R/B-B/B CONNECTING SERVICE TUNNEL, 2 connected cells
15	R/B-EDG/B CONNECTING SERVICE TUNNEL, 1 cell * 3 division
16	LIGHT OIL STORAGE TANK (LOT) FOUNDATION
17	B/B-LOT CONNECTING SERVICE TUNNEL, 1 cell
18	R/B-CST-Rw/B CONNECTING SERVICE TUNNEL, 1 cell
19#	SUPPRESSION POOL TANK (SPT) STRUCTURE
20#	R/B-SPT CONNECTING SERVICE TUNNEL
21	FLSS WATER STORAGE TANK (FLSS WST) FOUNDATION
22	B/B-FLSS WST CONNECTING SERVICE TUNNEL, 2 connected cells
23	FILTER VENT BUILDING (Fv/B)
24#	DIVERSE ADDITIONAL GENERATOR (DAG) AREA

Note:
1. This drawing is only indicative. Final position of structures will be based on site location. See each structural design report for the assumed size in GDA.
2. The civil engineering, i.e. general arrangement and structural design of No 7, 12, 19, 20, 24 (shown with “#” in the table above) are NOT included in the GDA.

Figure 7.1-1: UK ABWR Power Station Site Layout for GDA

A summary of each of the main buildings in scope of GDA is provided in the following paragraphs [Ref-19].

Reactor Building (R/B)

The R/B is a reinforced concrete structure forming the Secondary Containment which houses the Primary Containment (the RCCV and steel drywell head which surround the RPV), along with the drywell, the wetwell and the Suppression Pool (S/P). The R/B also contains: the major portions of the Nuclear Steam Supply System (NSSS), the steam tunnel, the Spent Fuel Pool (SFP), the refuelling area, the essential power, the non-essential power, the ECCS, the R/B HVAC and other support systems.

Turbine Building (T/B)

The T/B houses all the components associated with the power conversion and auxiliary systems. This includes a portion of the Main Steam System (MS) on the turbine side (running from the R/B), the turbine-generator, the main condenser, the turbine bypass system, condensate demineralisers, the steam jet air ejector, the Off-Gas system (OG), and the condensate and feedwater pumping and re-heating equipment.

Control Building (C/B)

The C/B includes the MCR, the computer facility, the cable tunnels, some of the plant essential switchgear, some of the essential power and the essential HVAC system. The MS tunnel from the R/B to the T/B is located in the ground floor of the C/B.

Radwaste Building (Rw/B)

The Rw/B houses equipment associated with the collection, segregation (where it is not feasible at the point of generation) and treatment of the liquid and wet solid radioactive waste generated in the plant.

Service Building (S/B)

The S/B houses the following facilities: administration; access control and security to the R/B; the Health Physics laboratory; laundry and changing rooms. The principal function besides housing the administrative operations of the plant is to control access to and egress from the R/B complex.

7.2. Definition of UK ABWR Operating Condition

The UK ABWR lifecycle is broken down into discrete stages, specifically construction, commissioning, commercial operation and decommissioning. The commercial operation stage is often referred to as ‘normal operation’. Normal operation is a formally defined ‘Operating Condition’ and consists of several Operating Modes such as start-up, power operation, shutdown, etc. [Ref-35].

The ONR assess the safety aspects of all Operating Conditions across all Operating Modes. The scope of the Environment Agency's assessment regarding environmental impact is defined in the P&ID, and focuses on ‘normal operation’ only. ‘Normal operation’ is described in the P&ID [Ref-1] as follows:

> *“'Normal operation' includes the operational fluctuations, trends and events that are expected to occur over the lifetime of the facility, such as start-up, shutdown, maintenance, etc. It does not include increased discharges arising from other events, inconsistent with the use of BAT, such as accidents, inadequate maintenance, and inadequate operation.”*

The PCSR defines the different UK ABWR Operating Conditions to give consistent scope and wording, as specifically used in Mechanical Engineering (ME) and Structural Integrity (SI) work. The definition of ‘normal operation’ defined in the P&ID is broadly equivalent to Operating Condition I as described in Generic PCSR Sub-chapter 5.4 [Ref-35].

Hitachi-GE interprets ‘normal operation’ as all the Operating Modes including events that are expected to occur during commercial operation. Hence, Hitachi-GE generally uses the term ‘normal operation’ to mean Operating Conditions that are in-scope of the GEP submission (though the term Operating Condition I may also be used). A comparison of the terminology of Operating Conditions and Operating Modes is summarised in Table 7.2-1 below.

Table 7.2-1: Comparison of the Definition of Operating Conditions and Operating Modes used for the GEP submission and Generic PCSR

<table>
<tr><th>Category</th><th>Operating Condition</th><th colspan="5">Operating Mode</th></tr>
<tr><td>GEP submission</td><td>Normal operation</td><td>Start-up</td><td rowspan="2">Power operation</td><td colspan="2">Shutdown</td><td>Maintenance/ Outage</td></tr>
<tr><td>Generic PCSR (e.g. ME, SI)</td><td>Operating Condition I</td><td>Start-up</td><td>Hot shutdown</td><td>Cold shutdown</td><td>Refuelling outage</td></tr>
</table>

8. Minimisation of Environmental Impacts

In common with all nuclear power stations and many other industrial-scale activities, operation of the UK ABWR has potential radiological and conventional (i.e. non-radiological) environmental impacts, both of which are covered by the GEP application. The systems and mechanisms that produce radioactive wastes are illustrated in Figure 8.1-1 and Figure 8.1-2 Quantification of the proposed radioactive discharges and their radiological impacts to the public and non-human species (NHS) at a generic site are summarised in Section 8.2. The conventional (i.e. non-radioactive) environmental impacts are summarised in Section 8.3.

8.1. An Integrated Waste Strategy

The waste management strategies for all radioactive and non-radioactive waste, including SF, produced by the UK ABWR during construction, operation and decommissioning are considered together in the Integrated Waste Strategy (IWS) document [Ref-36].

All identified wastes are shown to have a management strategy and identified routes for disposal. The management strategies have been chosen following a standardised approach that has included due consideration of the following:

- Compliance with regulations (including Site Licence Conditions and Environmental Permit Conditions) and Government policy to progressively reduce discharges.
- Health and safety to workers and the public as well as the effect on the environment.
- Application of the waste hierarchy to minimise waste.
- Application of BAT.

The IWS is a live document that will be reviewed and re-issued during the progression of the GDA. The GDA IWS is expected to form the basis of a site-specific IWS to be developed at a later stage by a future site operator for an operational UK ABWR site.

The following waste management sections summarise the IWS input information from the relevant referenced GEP documents.

8.1.1. Non-radioactive (Conventional) Waste Management

Conventional wastes will be generated throughout the lifecycle of the UK ABWR site during construction, operation and decommissioning.

Conventional solid waste

The IWS presents the strategies for conventional solid waste. Examples of this waste include:

- Inert waste: rubble, concrete and glass etc;
- Non-hazardous waste: including metal, cardboard, plastic, wood, office waste and canteen waste; and,
- Hazardous waste: including waste electrical and electronic equipment, thermal insulation, oil, chemically contaminated soil / concrete.

Conventional wastes will be collected on site, sorted and stored in appropriate conditions before removal from site. Specialist waste treatment or disposal contractors will be used to remove, treat (where applicable) and dispose of wastes such that:

- Personnel safety is assured;
- The waste hierarchy is applied and materials are re-used or recycled where possible;
- Storage of wastes will be appropriate to their form and hazard and mitigate risks of potential release to ground, water or air;
- Hazardous materials are treated by specialist contractors appropriate to the material type and hazard;
- The proximity principle is followed, using local licensed contractors where practicable for transport, treatment and disposal; and,
- Any regional waste management plans are taken into consideration.

Conventional liquid and gaseous waste

The non-radioactive liquid and gaseous strategy, systems and environmental impacts are presented in the Other Environmental Regulations document [Ref-13] and summarised in Section 8.3 this GEP summary document.

8.1.2. Radioactive Waste Management

This section provides an overview of the radioactive waste management systems of the UK ABWR. More detailed information on the gaseous, liquid and solid radioactive waste management strategies for the UK ABWR is presented in the RWMA document [Ref-9]. The RWMA document demonstrates that the radioactive waste management strategies that are applied to all radioactive waste streams take due consideration of relevant international and UK policy, regulatory requirements and guidance, and hence will support future site-specific Environmental Permit and Site Licence applications.

Figure 8.1-1 is a simplified representation of the three main radioactive waste routes (gaseous, liquid and solid) from generation to discharge (gaseous and liquid) or disposal (solid).

The Main Stack discharges to atmosphere the radioactive gaseous waste from the treatment systems of the Off-Gas (OG) system and ventilation air from certain radiologically-controlled buildings (HVAC). The aqueous liquid wastes are treated in the liquid waste treatment system prior to either recirculation and reuse, or discharge to sea from a common discharge point. Solid radioactive waste is segregated, managed, treated (where identified as appropriate) and conditioned before either prompt off-site disposal or on-site interim storage awaiting the future availability of the Geological Disposal Facility (GDF).

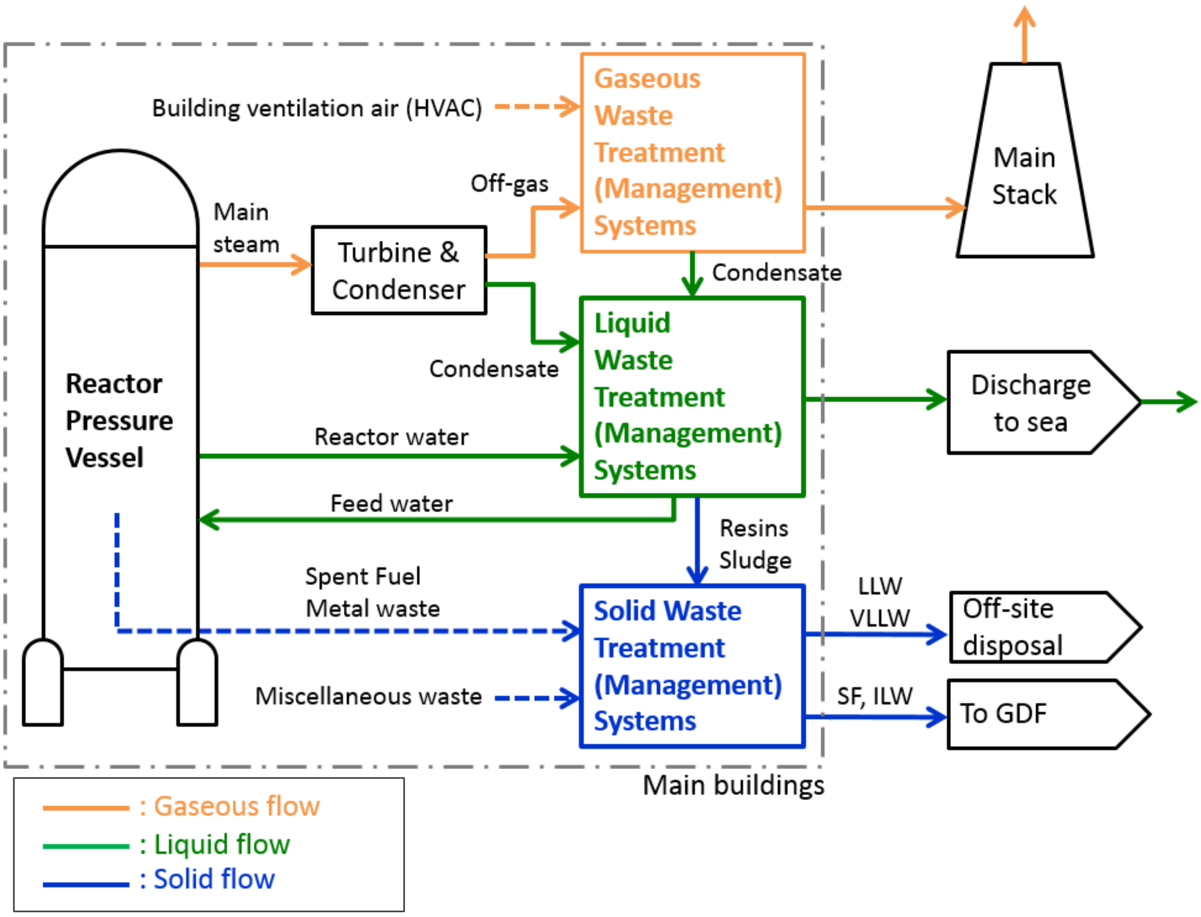


Figure 8.1-1: Overview of UK ABWR Waste Generation Routes

The three waste management systems are presented in expanded detail in Figure 8.1-2, which also identifies the main waste management system components and the buildings in which they are housed. They are identified as the:

- Off-Gas Radioactive Waste Management System (shown in orange);
- Liquid Radioactive Waste Management System (shown in green); and,
- Solid Radioactive Waste Management System (shown in dark blue).

Short summary descriptions of each of the three main systems are given in the following sections. Further details of the waste management strategies and the waste management system designs are provided in the RWMA document [Ref-9], Demonstration of BAT [Ref-10] and PCSR Chapter 18 Radwaste [Ref-5] and the references therein.

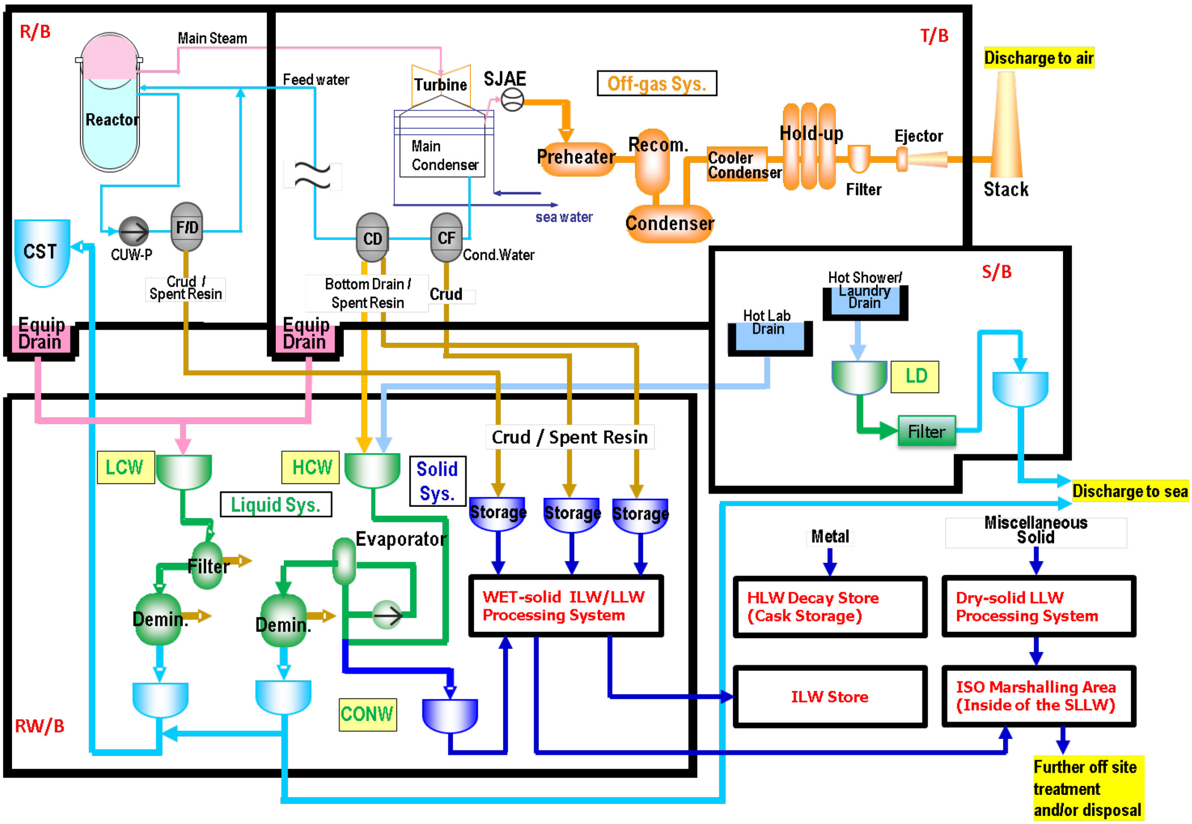


Figure 8.1-2: Outline of Radioactive Waste Management System

CD: Condensate Demineraliser
CF: Condensate Filter facility
CONW: Concentrated Waste system
CST: Condensate Storage Tank
CUW: Reactor Water Clean-up system
CUW-P: Reactor Water Clean Up Pump
Demin: Demineraliser
F/D: Filter Demineraliser
HCW: High Chemical impurities Waste system
LCW: Low Chemical impurities Waste system
LD: Laundry Drain system
R/B: Reactor Building
Rw/B: Radwaste Building
S/B: Service Building
SJAE: Steam Jet Air Ejector
T/B: Turbine Building

8.1.2.1. Gaseous Radioactive Waste Management System

The Off-Gas System (OG)

The OG (depicted in orange in Figure 8.1-2) has been developed to address three primary functions:

1. To maintain the main Condenser vacuum by extracting non-condensable gas.
2. To safely recombine flammable gases (hydrogen and oxygen), which are generated by radioactive decomposition of reactor cooling water, to reduce the possibility of an explosion from the build-up of radiolytic hydrogen. This does not contribute to the environmental performance of the NPP and the specification and performance of this system is addressed in detail within the PCSR Chapter 18 [Ref-5].
3. To minimise and control the release of radioactive gases into the atmosphere by delaying and filtering the off-gas waste process stream to adequately decay short-lived radioactive isotopes and filter out particulate matter, thus keeping releases within discharge limits.

To achieve function 3, the moisture in the gas stream is first condensed, and then the remaining non-condensable gases (principally air with a small amount of radioactive Argon, Krypton and Xenon gas) are extracted and passed through OG charcoal adsorber beds. These adsorbers provide adequate 'hold-up' or 'delay' to allow time for the radioactive gases to decay to lower activity levels before leaving the system. After this processing step, the treated gaseous waste is monitored and released to the environment through the Main Stack.

The HVAC system

The HVAC system is identified as "building ventilation air" in Figure 8.1-1. The functions of the HVAC system that are of relevance to the management of gaseous radioactive wastes are: limiting and containing the possible release of radioactive materials from plant and equipment in a room/area during normal operation or maintenance/inspection; and, where necessary, filtering contaminated air prior to its discharge to atmosphere.

The buildings identified with potential to generate gaseous radioactive wastes, due to the inventories within them, are the R/B, the T/B, the Rw/B, the S/B and the solid waste treatment facilities. Radiologically-controlled area HVAC systems will include high-efficiency particulate air (HEPA) filters on their discharge. Where practicable, and where required to provide adequate dispersion, the HVAC systems will discharge to the environment via the main stack. The HVAC system discharge from the Main Stack also includes the tank vents/extracts from the various tanks in the Rw/B which join the Rw/B HVAC system ducting before it exits the Rw/B.

Gaseous discharges to the environment and their radiological dose implications are discussed in Section 8.2.

8.1.2.2. Liquid Radioactive Waste Management System (LWMS)

The LWMS (depicted in green in Figure 8.1-2) is designed to control, collect, process, handle, store, and dispose of radioactive waste water generated during operation of the UK ABWR reactor and turbine. All potentially radioactive waste waters are collected in sumps or drain tanks at various locations in the plant and transferred to collection tanks within the Rw/B.

The LWMS has been designed to recycle as much of the treated waste water back into the reactor cooling water system as possible. An exception is waste water which contains detergent impurities (arising from the laundry and showers) which are incompatible with the reactor and fuel pool water systems.

The LWMS is divided into several sub-systems: the High Chemical impurities Water (HCW), the Low Chemical impurities Water (LCW), Laundry Drain (LD) and Controlled Area Drain (CAD). The sub-systems segregate waste water with differing characteristics (i.e. type of impurity or chemical content) enabling appropriate and efficient treatment prior to re-use or eventual disposal. In a situation where the waste water output from a treatment system is found to be outside re-use parameters or disposal limits, the waste water treatment systems have the ability to cycle the waste water back through the treatment systems until the relevant parameters or limits are met.

Despite the aim to re-use the waste water, there may be times when liquid discharges are necessary due to capacity limits for on-site storage of treated liquid waste being reached. Information provided as part of the GEP submission shows that the frequency, volume and contaminant loading of such liquid discharges are reduced to a very low level, in line with the application of BAT [Ref-9] [Ref-10].

The LWMS normally operates on a batch basis. Provision is made for sampling and analysis at important process points and from the discharge tank to ensure that process parameters and discharge limits are met. Protection against accidental discharge is provided by detection of abnormal conditions and subsequent alarms, as well as by operational procedures.

System components such as tanks, processing equipment, pumps, valves, and instruments that may contain radioactivity are arranged in appropriately shielded, access-controlled containments to minimise radiation exposure of plant personnel and to prevent or minimise radiation dose or release to the environment.

During operation, the LWMS will generate solid wastes that include those known as 'cruds or sludges', spent filters and spent ion exchange resins. The solid wastes will be treated and disposed according to the Solid Radioactive Waste Management System (see Section 8.1.2.3).

At decommissioning, the water within the reactor and fuel pool systems will be treated and discharged using the systems identified above as far as practicable. Redundant items of plant and equipment will be managed according to the Solid Radioactive Waste Management System (see Section 8.1.2.3).

Liquid discharges to the environment and their dose implications are discussed in Section 8.2.

8.1.2.3. Solid Radioactive Waste Management System (SWMS)

Solid radioactive wastes are produced during the operational and decommissioning phases of a power station's lifecycle. The UK ABWR design has a waste management strategy and system based on available treatment technologies and current and known future disposal facilities. The strategy takes due consideration of waste source, categorisation and type. It has been developed using BAT decision-making methodologies.

The SWMS (depicted in dark blue in Figure 8.1-2) is designed to control, segregate, collect, handle, process, package, and temporarily store wet and dry solid radioactive waste prior to dispatch for off-site disposal.

Waste categories

In the UK, radioactive wastes are classified in terms of the nature and quantity of radioactivity that they contain, as well as their heat-generating capacity, as follows [Ref-37]:

- Very Low Level Waste (VLLW) is a subset of LLW that includes wastes with maximum concentrations of 4 MBq per tonne of total activity, or 40 MBq per tonne for tritium total activity, that can be disposed to specified landfill sites.
- Low Level Waste (LLW) is waste having a radioactive content not exceeding 4 GBq per tonne of alpha activity, or 12 GBq per tonne of beta/gamma activity. Currently available re-use, recycling, volume reduction and disposal options are:
    - Re-use of plant or equipment at another site;
    - Metal waste treatment to enable recycling of as much material as possible;
    - Incineration to reduce the volume of combustible waste;
    - Super compaction to reduce the volume of compactible waste;
    - Disposal to the Low Level Waste Repository (LLWR).
- Intermediate Level Waste (ILW) is waste exceeding the upper boundaries for LLW, but which does not require heat generation to be taken into account in the design of storage or disposal facilities. Wastes that are or will be demonstrably ILW at the time of disposal will be consigned to the future GDF[3].
- High Level Waste (HLW), which includes SF, is waste in which the temperature of the waste may rise significantly as a result of radioactivity (i.e. decay heat), so this factor has to be taken into account in the design of storage or disposal facilities. Wastes that are HLW will be consigned to the future GDF.

[3] https://www.gov.uk/government/publications/implementing-geological-disposal

Waste management solutions

Waste management strategy on UK nuclear sites, including both short-term on-site interim storage and long-term disposal routes (as well as approaches to matters such as reprocessing) are largely governed by policy set by UK Government.

The RWMA document [Ref-9] describes the BAT options selected for the management and disposal of UK ABWR waste. The waste descriptions, their category and BAT disposal option(s) are summarised in Table 8.1-1.

Table 8.1-1: Summary of SWMS Solutions

Category	Description	Treatment	Disposal
VLLW	Miscellaneous dry, low activity wastes including metals, concrete, cloths, paper, etc.	Recycle metals where practicable, compaction and incineration where possible and direct disposal of remainder to permitted disposal site.	
LLW	Miscellaneous non-combustible: Metals, pipes, filters, cables, lagging, concrete, glass.	Metal treatment, super compaction where practicable.	LLWR
LLW	Miscellaneous combustible: filters, plastic sheets, paper, wood, cloth, oil, activated carbon.	Incineration (off-site supplier).	Ash to LLWR
LLW	Wet solid waste: concentrate (sludge), ion exchange resin, activated carbon.	Solidify to passive waste form with cement formulation in LLW disposal container (on-site).	LLWR
ILW	Activated metals	On-site decay storage as necessary, condition in ILW disposal container.	Interim storage* then GDF.
	Wet solid waste: crud / sludge, ion exchange resin.	Solidify to passive wasteform with cement formulation in ILW storage and disposal container (on-site).	Interim storage* then GDF.
HLW	Spent Fuel	On-site decay storage, condition for disposal.	Interim storage* then GDF.

* Interim storage is estimated to be minimum 140 years after cessation of power plant operations for Spent Fuel, and 100 years for ILW.

The RWMA also presents example facilities capable of treating, interim and decay storing (where appropriate) and managing the disposal of solid radioactive wastes in accordance with the chosen BAT option. These interim storage facilities will be amongst the last buildings to be removed from site once the stored ILW and SF have been consigned to the GDF. This may be minimum approximately 140 years after the power station site has ceased power generation and entered the decommissioning phase.

The solid radioactive waste inventory is presented in Appendix A of the RWMA document [Ref-9]. Table 8.1-2 below shows the approximate quantities of radioactive waste that it is estimated will be produced by an individual UK ABWR during 60 years' of operation.

Table 8.1-2: Summary of Estimated Solid Radioactive Waste Quantities

Waste category	Waste quantity untreated per year		Treated (on-site) waste volume for disposal per year
	Volume (m^3)	Mass (t)	(m^3)
Operations phase			
VLLW	17	6	6
LLW	85	43	74
ILW	6 (wet solid waste only)	2 (dry solid waste only) 7t Fuel channels (stored with SF assemblies)	Interim storage ~100 years awaiting disposal to the GDF.
Decommissioning phase			
Non-radioactive waste to provide context		633,180	-
VLLW	-	23,010	-
LLW	-	11,470	-
ILW	-	800	-
SF	9600 units over 60 years' operation, interim stored ~140 years awaiting disposal to the GDF.		

8.2. Discharges and Dose Implications

The Quantification of Discharges and Limits document [Ref-12] describes the approach that Hitachi-GE has adopted to estimate the radioactive discharges from the UK ABWR and to propose annual discharge limits for an individual UK ABWR unit. The Prospective Dose Modelling document [Ref-7] uses the proposed discharge limits to estimate the radiological dose implications to the public and NHS.

The following background information is provided to give some context to the UK ABWR radiological dose information presented here and to aid understanding:

Radiation describes any process in which energy travels through a medium or through space (other than via conduction or convection). There are two types of radiation: ionising and non-ionising. Ionising radiation comes from the atoms of radioactive materials becoming stable by emitting energy or particles through a process called 'radioactive decay'; the energy or particles (radiation) have enough energy to interact with matter in other materials. The second type of radiation, non-ionising radiation, is usually electromagnetic radiation such as radiowaves. For the purpose of nuclear facility dose assessments only ionising radiation is considered and quantified.

The radiological impact from nuclear facilities is quantified using the following SI units: Becquerels (Bq) and Sieverts (Sv). A Becquerel is a measure of radioactive decay of a material and is an extremely small unit: 1 Bq = 1 disintegration of an atom per second. The Sievert is a measure of the health effect of ionising radiation on the human body and is used to quantify the health effect of exposure to a radiological source (either externally of through inhalation or ingestion). The Sievert is an extremely large unit and most figures are given in milli-Sieverts (mSv) (thousandths of a Sievert) or micro-Sieverts (µSv) (millionths of a Sievert).

The local population for whom dose assessments are calculated are represented by a model group. The effect of differing characteristics can be assessed (for example geographic location, habits and diet) with the different groups characterised with relevant names such as Fisherman, Local Resident etc. Doses can be calculated for different ages within these groups too (for example, Infant, Child, Adult etc.).

The ICRP (International Commission on Radiological Protection) refer to these model groups as the 'representative person'. The representative person is defined as an individual receiving a dose that is representative of the more highly exposed individuals in the population. Those individuals who, due to their specific characteristics and exposure pathways, receive the greatest dose in the local population are termed 'most exposed individuals'.

Exposure of local individuals and local population groups is measured in Sieverts and dose assessments can determine a 'collective dose' for a population. This can be thought of as representing the total radiological consequences of discharges to a population, over a defined period of time. This collective dose will consider the doses received from site gaseous and liquid discharge, normally reported separately. Direct shine, which can be viewed as the dose emitted from the site itself under normal operating procedure, must also be considered.

The Environmental Permitting (England and Wales) Regulations 2016 (EPR2016) [Ref-38] (as amended) and the Ionising Radiations Regulations 1999 [Ref-39] apply limits and constraints on the annual radiation exposure of members of the public. The principal aims of the legislation are that the Environment Agency, or NRW, in exercising their duties and functions under the regulations, ensure that:

- All exposures to ionising radiation of any member of the public and of the population as a whole resulting from the disposal of radioactive waste are kept as low as reasonably achievable (ALARA), taking into account economic and social factors;
- The sum of the doses arising from such exposures does not exceed the individual public dose limit of 1mSv per year;
- The individual dose received from any new discharge source since 13th May 2000 does not exceed 0.3mSv per year; and
- The individual dose received from any single site does not exceed 0.5mSv per year.

Again, the following background information is provided to give some context to the dose information presented here and to aid understanding:

It is the remit of Public Health England (PHE) (formally the Health Protection Agency (HPA)) to establish the average annual radiological dose to UK citizens: this currently sits at an average dose of 2.7 mSv per year [Ref-40]. According to their data approximately 85% of this is from natural radiological sources such as radon gas emission from the ground and cosmic radiation [Ref-41]. A minority percentage (approximately 17%) is attributed to artificial doses, with medical exposure contributing the majority at 15.5% (17% of medical exposure arises, for example, through the use of X-rays [Ref-41]).

When discussing radiation dose from nuclear facilities it is important to keep a relative view on discharge and direct dose values in comparison to those UK citizens naturally receive. As shown above, EPR10 states that the sum of exposures from an operational nuclear site must not exceed an annual dose to the local representative person of more than 1 mSv/y. Figures published by PHE show that this is less than either: a single CT scan of the head, which would supply a dose of 1.4 mSv/y ; or the annual dose you would receive if you lived in Cornwall for a year due to the levels of natural radon gas emission from the ground (7.8 mSv/y) [Ref-41]. Therefore, the radiological impact of normal operations for generating nuclear power facilities is such that no significant increase in the representative person's dose or health impacts should be seen.

The proposed discharge limits for the UK ABWR result in doses that comply with all regulatory requirements. A summary of the methodologies used and results calculated is given in the sections below, with the full detail presented in the Quantification of Discharges and Limits [Ref-12] and the Prospective Dose Modelling document [Ref-7].

8.2.1. Quantification of Discharges and Limits

The Quantification of Discharges and Limits document [Ref-12] describes Hitachi-GE's approach to quantifying radioactive discharges during normal operation and to deriving the proposed discharge limits; it presents in full the estimated discharges (estimated on a monthly basis and shown for each discharge point and route) and the proposed annual discharge limits.

European Commission guidance [Ref-42] provides a comprehensive list of key radionuclides to be monitored and reported in a standard format. These key radionuclides represent categories of radionuclides or a specific type of radiation, are significant in terms of radiological impact and suitable measurement sensitivity indicators. The evaluation of the radioactivity in the UK ABWR discharges considered this guidance and, in addition, used rigorous analytical methods supported by data from operating plants to define the radionuclides produced during normal operations. The discharge routes have been identified and account taken of the duration of the planned operational cycle, expected events and the various operation modes, in estimating the fission product, activation product and actinide content in the reactor steam and water.

Figures 8.2-1 and 8.2-2 summarise the origin and processing route of the radionuclides routinely discharged to the environment during normal operations via the liquid waste management and gaseous waste management systems previously introduced in Section 8.1.2. It is important to note that these releases are within operating limits, which are established to ensure any potential harmful impacts to population or environment are minimised during normal operations.

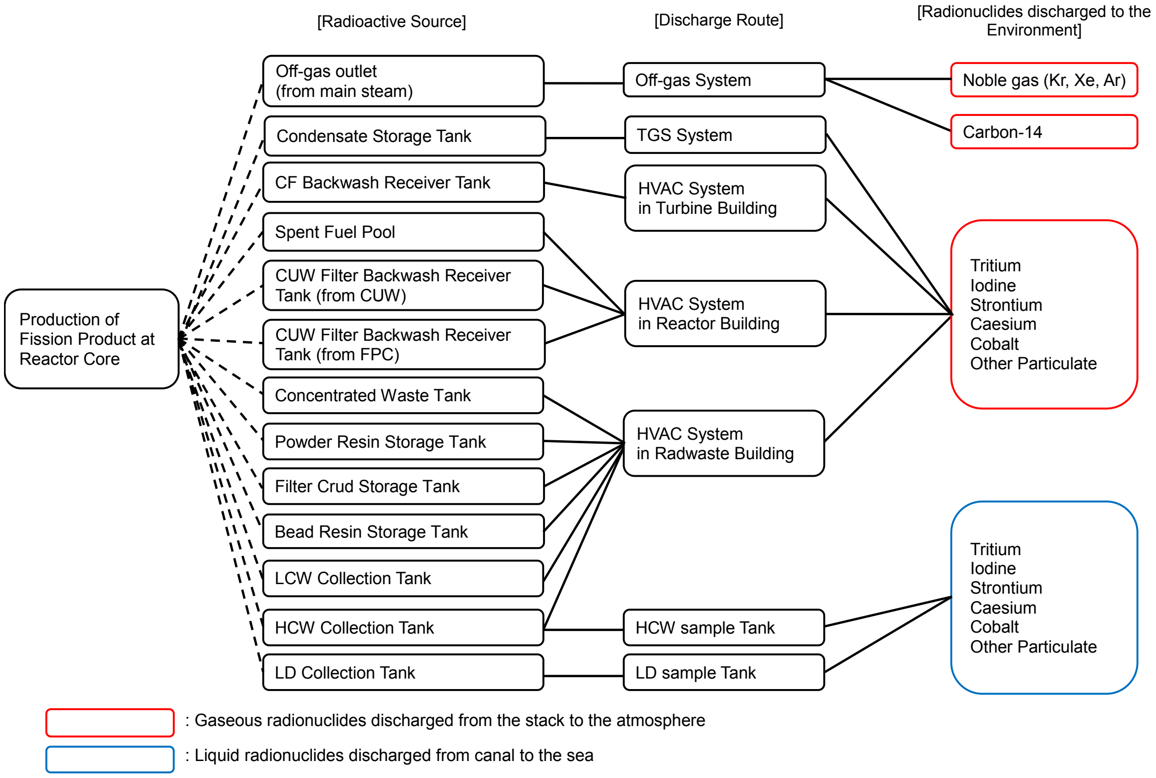


Figure 8.2-1: Summary of Discharged Activity Origin and Route During Operation, Start-up and Shut-down

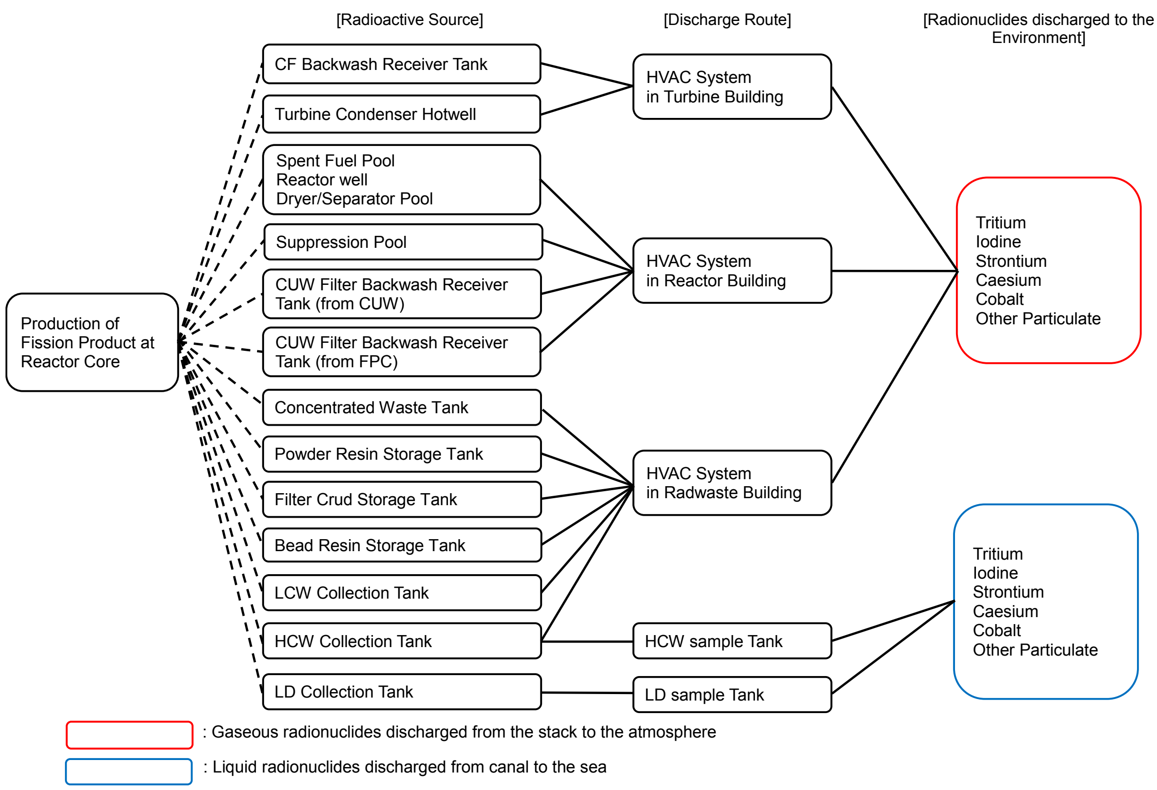


Figure 8.2-2: Summary of Discharged Activity Origin and Route During Outage

The effect of ‘expected events’ (events which occur during normal operations which are not safety-related but which result in an increase in discharges over a defined period) is also presented in the Quantification of Discharges and Limits document [Ref-12]. The only expected event associated with the normal operation of the UK ABWR is an isolated ‘fuel pin failure’ (an increase in the release of gases from a fuel pin due to a change in properties of the fuel pin cladding material). There is a consequent small increase in the amount of some radionuclides in the gaseous discharges during the short timeframe of an expected event (typically up to 14 days).

The basis upon which discharged radionuclides are selected for permitting (i.e. have a discharge limit set by the Environment Agency or NRW) is published in Environment Agency guidance [Ref-43]. The guidance indicates that the regulators will normally set annual site limits for each radionuclide, or group of radionuclide(s) that meet certain parameters during normal operation. The parameters are given as radionuclides or groups of radionuclides that:

a. are significant in terms of radiological impact on people (that is, the dose to the most exposed group at the proposed limit exceeds 1 μSv per year);
b. are significant in terms of radiological impact on NHS (this only needs to be considered where the impact on reference organisms from the discharges of all radionuclides at the proposed limits exceeds 40 μGy/h);
c. are significant in terms of the quantity of radioactivity discharged (that is, the discharge of a radionuclide exceeds 1 TBq per year);
d. may contribute significantly to collective dose (this only needs to be considered where the collective dose truncated at 500 years from the discharges of all radionuclides at the proposed limits exceeds 1 man Sievert per year to any of the UK, European or World populations);
e. are constrained under national or international agreements or is of concern internationally;
f. are indicators of plant performance, if not otherwise limited on the above criteria; and
g. for the appropriate generic categories from the RSR Pollution Inventory (e.g. ‘alpha particulate’ and ‘beta/gamma particulate’ for discharges to air) to limit any radionuclides not otherwise covered by the limits set on the above criteria.

Using these parameters as a basis, each of the radionuclides present in the UK ABWR discharges is examined to determine whether it is appropriate for limit-setting.

The Environment Agency guidance on limit setting [Ref-43] allows for operational flexibility between the optimised discharge level and the permitted discharge level. This allowance has been termed a “headroom factor”. Therefore a headroom factor is proposed for each radionuclide or group of radionuclides selected for permitting, to allow for some operational flexibility in the early years of operation for the UK ABWR. The approach to proposing limits for the UK ABWR is defined as:

Proposed Annual limit = (annual discharge x headroom factor) + expected event discharge

Using the approach outlined above, Hitachi-GE has proposed limits shown in Table 8.2-1 and Table 8.2-2 for the UK ABWR:

Table 8.2-1: UK ABWR Liquid Discharge Proposed Limits

Radionuclide (or group)	Proposed Annual Limit (Bq)
Tritium	7.6E+11

Table 8.2-2: UK ABWR Gaseous Discharge Proposed Limits

Radionuclide (or group)	Proposed Annual Limit (Bq)
Tritium	1.0E+13
Carbon-14	1.7E+12
Argon-41	5.2E+12
Noble Gases (group, excluding Ar-41)	2.2E+11

8.2.2. Prospective Dose Implications

The proposed discharge limits have been used in a dose modelling study to estimate the potential radiological dose implications for members of the public and the NHS at a generic site (as defined in [Ref-6]): the Prospective Dose Modelling document [Ref-7] describes the modelling work undertaken, including the relevant inputs and assumptions, and the results obtained from the study.

Modelling Methodology

The UK environment agencies, together with PHE and the Food Standards Agency, have developed a simple and cautious assessment methodology of the critical group dose for the prospective assessment of public doses; this is known as the Initial Radiological Assessment Tool methodology [Ref-44] [Ref-45]. The IRAT methodology supports a staged approach to the dose assessment process, with each successive stage representing a more sophisticated approach to the modelling. If the predicted dose is less than 20µSv/y following the first stage calculation then no more detailed dose assessment is necessary. Where the predicted dose exceeds 20µSv/y, then it is necessary to move to the Stage 2 and carry out a more detailed and realistic assessment. Similarly, if the predicted dose exceeds 20µSv/y at the end of Stage 2 then Stage 3 calculations are completed.

The stages and methodologies used by Hitachi-GE are summarised as follows:

- Stage 1: uses the IRAT methodology and standard generic parameters which enable a cautious assessment of the radiological impact of discharges. If the assessed dose is > 20µSv/y, then proceed to Stage 2:

- Stage 2: uses the IRAT methodology and refined data with more realistic parameters. If the assessed dose is > 20µSv/y, then proceed to Stage 3*:*

- Stage 3: uses more detailed site data and more detailed codes (in the case of Hitachi-GE, PC-CREAM 08®) to give greater accuracy. The computer code PC-CREAM 08® is made up of a number of modules that predict the transfer of radionuclides in the environment and also estimate build-up of radionuclides in the environment and the effect on NHS.

A number of assumptions about the way the UK ABWR will be operated were made and used at each stage of the modeling study; these include the length of operating life (60 years) and the activity of the continuous and short-term discharges (as defined in [Ref-12]). By varying input parameters defining the behaviour of different receptors (such as the amount of time spent in different locations and diet contents), the IRAT methodology used in Stages 1 and 2 enables the assessment of doses for different representative local groups (for example, so-called Local Resident family, Fisherman family etc) and age groups (Adult, Child, Infant and Foetus). This allows assessment of (amongst other things):

- Doses to the most exposed members of the public;
- Doses to representative members of the public; and,
- The dose rate to NHS.

Hitachi-GE has made assessments of the radiological impact of discharges to air and to coastal waters only; as described in the Generic Site Description [Ref-6], for the purposes of the GDA, it is assumed that discharges will not be made into rivers or streams or into public sewers, nor is on-site incineration carried out. As a result, these routes are not assessed.

For all stages, the effect of direct radiation "shine" from buildings on-site has also been included in the overall doses calculated. Regulation of on-site dose falls under the remit of the ONR, however, direct shine that has an impact off-site needs to be taken into account in the dose assessments required by the Environment Agency as detailed in the P&ID. PCSR Chapter 20 Radiation Protection (sub-chapter 20.7) [Ref-24] details the methodology underpinning the direct shine results utilised in the dose modelling of the GEP.

Modelling Results

The results presented in Prospective Dose Modelling document [Ref-7] demonstrate that, using cautiously derived data and modelling at the proposed annual discharge limits, the radiological impacts of the UK ABWR are within the relevant dose constraints and dose limits. Summary information for the requirements laid out in the P&ID is presented in Table 8.2-3; full detail on the methodology, assumptions, derivation and interpretation of all results can be found in the Prospective Dose Modelling document [Ref-7] and should be read to give full context to the information presented here.

Table 8.2-3: Prospective Modelling Results

<table>
<tr><th>P&ID information requirement
(see section 7 in table 1 [Ref-1])</th><th>Results of the UK ABWR assessment undertaken</th></tr>
<tr><td>Annual dose to the most exposed members of the public for liquid discharges</td><td>Using the Stage 3 methodology and parameters, the predicted doses to the most exposed Adult, Child and Infant due to liquid discharges are found to be 2.29E-04, 6.17E-05 and 5.37E-06µSv/y, respectively.

These predicted doses are very low and do not approach any dose constraint or limit.</td></tr>
<tr><td>Annual dose to the most exposed members of the public for gaseous discharges (identifying separately the dose associated with on-site incineration where applicable)</td><td>Using the Stage 3 methodology and parameters, the predicted doses to the most exposed Adult, Child and Infant due to gaseous discharges are found to be 12.7, 14.0 and 23.5µSv/y, respectively.

These predicted doses are very low. The predicted doses to the Adult and Child groups do not approach any dose constraint or limit. The predicted dose for an Local Resident Infant exceeds 20µSv/y but remains well below the source and site constraints and the dose limit. It is considered that further refinement is not warranted as part of GDA.

No on-site incineration is required by the UK ABWR therefore no separate assessment has been made.</td></tr>
<tr><td>Annual dose from direct radiation to the most exposed member of the public</td><td>• At the site boundary the annual external dose was found to be 9.40E-01 µSv/y.
• At 500 m from the source buildings the annual external dose was found to be 1.75E-01µSv/y.
• At 1000 m from the source buildings the annual external dose was found to be 8.24E-03µSv/y.

These predicted doses are very low and do not approach any dose constraint or limit.</td></tr>
<tr><td>Annual dose to the most exposed members of the public for all discharges from the facility</td><td><table><tr><th>Exposure pathway</th><th>Annual dose (µSv/y)</th><th>Most exposed age group</th></tr><tr><td>Liquid discharges</td><td>2.29E-04</td><td>Adult</td></tr><tr><td>Gaseous discharges</td><td>2.35E+01</td><td>Infant</td></tr><tr><td>Direct radiation</td><td>9.40E-01</td><td>Adult</td></tr><tr><td>Total</td><td>2.44E+01</td><td>--</td></tr></table>
Stage 3 methodology and parameters were used and the resulting predicted doses are very low. The predicted dose exceeds 20µSv/y but remain well below the source and</td></tr>
</table>

<table>
<tr><td></td><td>site constraints and the dose limit. It is considered that further refinement is not warranted as part of GDA.</td></tr>
<tr><td>Annual dose to the representative person for the facility</td><td>

Using the Stage 3 methodology and parameters, the annual dose to the representative person has been determined for the following population groups:
i. For gaseous discharges: a Local Resident family who also consume locally sourced seafoods at average rate;
ii. For liquid discharges: a Fisherman family who also consume locally sourced terrestrial foods at average rate.

Summary of Overall Dose for the Fisherman Family

<table>
<tr><th>Age group</th><th>Liquid discharges (μSv/y)</th><th>Gaseous discharges (μSv/y)</th><th>Direct exposure (μSv/y)</th><th>Total (μSv/y)</th></tr>
<tr><td>Adult</td><td>2.29E-04</td><td>5.95E+00</td><td>9.40E-01</td><td>6.89E+00</td></tr>
<tr><td>Child</td><td>6.17E-05</td><td>6.65E+00</td><td>4.70E-01</td><td>7.12E+00</td></tr>
<tr><td>Infant</td><td>5.37E-06</td><td>9.45E+00</td><td>3.20E-01</td><td>9.77E+00</td></tr>
</table>

Summary of Overall Dose for the Local Resident Family

<table>
<tr><th>Age group</th><th>Liquid discharges (μSv/y)</th><th>Gaseous discharges (μSv/y)</th><th>Direct exposure (μSv/y)</th><th>Total (μSv/y)</th></tr>
<tr><td>Adult</td><td>8.81E-06</td><td>1.27E+01</td><td>9.40E-01</td><td>1.36E+01</td></tr>
<tr><td>Child</td><td>9.54E-06</td><td>1.40E+01</td><td>4.70E-01</td><td>1.45E+01</td></tr>
<tr><td>Infant</td><td>2.18E-06</td><td>2.35E+01</td><td>3.20E-01</td><td>2.38E+01</td></tr>
</table>

These predicted doses are very low and do not approach any dose constraint or limit. The predicted dose for a Local Resident Infant exceeds 20μSv/y but remains well below the source and site constraints and the dose limit. It is considered that further refinement is not warranted as part of GDA.</td></tr>
<tr><td>Potential short-term doses, including via the food chain, based on the maximum anticipated short-term discharges from the facility in normal operation</td><td>

A summary of the predicted radiological impact to an Adult, Child and Infant is presented below:

Summary of Predicted Radiological Impact from Short Term Dose to Three Age Groups

<table>
<tr><th>Age group</th><th>Effective Dose from gaseous discharges (μSv)</th></tr>
<tr><td>Adult</td><td>1.86E-02</td></tr>
<tr><td>Child</td><td>1.68E-02</td></tr>
<tr><td>Infant</td><td>1.62E-02</td></tr>
</table>

These predicted doses are very low and do not approach any dose constraint or limit.</td></tr>
<tr><td>A comparison of the calculated doses with the relevant dose constraints</td><td>The estimates of the total prospective dose, including that due to direct exposure, are below the source and site constraints (0.3mSv and 0.5mSv respectively) and the legal limit for all age groups of all representative people. The estimates of the total prospective dose including that due to direct exposure are below 20μSv/y for all age groups in the Fisherman family group and for the Adult and Child age groups in the Local Resident family group. However, the annual dose for the Infant member of the</td></tr>
</table>

<table>
<tr><td></td><td>Local Resident group just exceeds 20 µSv/y. This indicates that some further refinement of the assessment should be considered. However, the data used is conservative and the calculated dose is greater than 20 µSv/y by only a small margin, therefore it is considered that further refinement is not warranted as part of GDA.</td></tr>
<tr><td>An assessment of whether the build-up of radionuclides in the local environment of the facility, based on the anticipated lifetime discharges, might have the potential to prejudice legitimate users or uses of the land or sea</td><td>Using IRAT Stage 1 methodology and parameters, it is predicted that the total activity concentration in seawater and seabed sediment due to liquid discharges at the proposed annual discharge limit is 0.238Bq/l in unfiltered sea water and 0.437Bq/kg in seabed sediment after 60 years of continuous discharge.

The total activities in soil are predicted to reach a total of 270Bq/kg after 60 years of continuous discharge, due principally to the accumulation of Tritium and C-14.

It should be noted that the above estimates of build-up in marine and terrestrial environments are based on the conservative and bounding parameters used for the Stage 1 assessments. Despite the conservatism in the assessment, it is concluded that impact of residual activity in the environment due to operation of an individual UK ABWR unit is negligible and will not restrict future use of the land and sea.</td></tr>
<tr><td>Collective dose truncated at 500 years to the UK, European and World populations</td><td>Collective Dose due to Liquid Discharges
<table>
<tr><th>Population</th><th>First pass (man Sv)</th><th>Global circulation (man Sv)</th><th>Total (man Sv)</th></tr>
<tr><td>UK</td><td>2.32E-07</td><td>1.53E-07</td><td>3.84E-07</td></tr>
<tr><td>EU12</td><td>5.95E-07</td><td>9.24E-07</td><td>1.52E-06</td></tr>
<tr><td>World</td><td>8.89E-07</td><td>2.57E-05</td><td>2.66E-05</td></tr>
</table>
Collective Dose due to Gaseous Discharges
<table>
<tr><th>Population</th><th>First pass (man Sv)</th><th>Global circulation (man Sv)</th><th>Total (man Sv)</th></tr>
<tr><td>UK</td><td>2.53E-01</td><td>1.78E-01</td><td>4.31E-01</td></tr>
<tr><td>EU</td><td>1.52E+00</td><td>-</td><td>-</td></tr>
<tr><td>EU12</td><td>-</td><td>1.08E+00</td><td>2.60E+00*</td></tr>
<tr><td>EU25</td><td>-</td><td>1.37E+00</td><td>2.89E+00**</td></tr>
<tr><td>World</td><td>-</td><td>2.99E+01</td><td>2.99E+01</td></tr>
</table>
*: Sum of first pass EU and EU12 global circulation
**: Sum of first pass EU and EU25 global circulation

The IAEA considers that practices giving rise to collective doses below 1 man Sv may be exempted from regulatory control. As can be seen above (using Stage 3 methodology and parameters), the predicted collective dose from an individual UK ABWR is within the 1 man Sv threshold for liquid discharges for all population groups. For gaseous discharges (using Stage 3 methodology and parameters) the 1 man Sv threshold is predicted to be exceeded for EU and World populations. The collective dose for these population groups is dominated by C-14.

As the collective dose from gaseous discharges exceeds the 1 man Sv threshold then the practice will not be exempted from regulatory control.</td></tr>
<tr><td>Dose-rate to NHS</td><td>This assessment is based on discharges at the proposed annual discharge limit and is based on Stage 1 parameters. The ERICA methodology is used and risk factors to the</td></tr>
</table>

	different reference species (or risk quotients, RQs) are calculated. These are calculated by dividing the predicted dose by the so-called "acceptable threshold" (different for different species). Therefore, a RQ value less than one means the predicted dose is lower than the threshold. For liquid releases to the environment all the reference species are calculated to have RQs orders of magnitude below 1, indicating the risk to marine biota due to the liquid radioactive discharges is very low. For gaseous discharges to the environment all the reference species are calculated to have RQs significantly less than 1 therefore indicating that the risk of exceeding the risk to terrestrial biota is very low.

8.3. Conventional Environmental Impacts

The Other Environmental Regulations document [Ref-13] presents the approach and results from the work undertaken by Hitachi-GE to quantify and assess the conventional environmental impacts of the UK ABWR, as required by regulations covering England and Wales. In line with the P&ID information requirements, it describes the potential UK ABWR impacts in several areas, specifically:

- Freshwater usage
- Seawater usage (for cooling)
- Fish deterrent and fish return systems
- Discharges to water courses
- Combustion plant

Note that the UK ABWR has no requirement for discharges to groundwater, nor does it require on-site storage of materials above the Control of Major Accident Hazards (COMAH) threshold during operation. As a result, these items are not summarised in this document. Full information on the assessments reaching these conclusions can be found in the Other Environmental Regulations document [Ref-13].

8.3.1. Freshwater Usage

The UK ABWR GDA is based on the assumption that all fresh water requirements will be supplied by the local water company and that fresh water abstraction, and an abstraction licence, will not be required.

Fresh water will typically be used for three purposes: domestic use, process use and fire-fighting during emergency scenarios. The process purposes include provision of reactor water, water for the auxiliary boiler system and the R/B and T/B closed loop cooling circuits (which then transfer the waste heat to the seawater cooling water system, described below). Many of these process uses are intermittent and therefore the overall site usage varies significantly from day to day (some estimates of usage are provided in section 4 of the Other Environmental Regulations document [Ref-13].

To ensure water is always available for the three broad categories of use outlined above, and to even out the demand on the water company, there are various water storage facilities on the site. It is not considered the predicted water usage rate will cause any significant environmental impact.

8.3.2. Seawater (Cooling Water) Usage

This document is based on the assumptions that the generic site is coastal and that a once-through seawater cooling system will be used. In general, the use of once-through cooling systems is considered BAT for a coastal location.

The seawater cooling systems of the UK ABWR are: the Circulating Water (CW) system, the Turbine Building Service Water System (TSW) and the Reactor Building Service Water System (RSW). The TSW and RSW are used to remove heat, via heat exchangers, from the closed loop R/B and T/B cooling systems described in section 6. There is no mixing of water or contaminants between the closed loop systems and the seawater systems.

The design of the CW, TSW and RSW systems will include a number of control measures to prevent fouling (physical, chemical, biological and mechanical). The control measures selected will depend in part on the characteristics of the receiving marine environment and therefore the detailed design will be finalised at site-specific stage. Further descriptions of these systems can be found in the Other Environmental Regulations document [Ref-13].

The CW flow rate in the UK ABWR once through seawater cooling system will be based upon a 12°C temperature increase between the inlet and outlet temperatures. The estimated hourly cooling water flows for the three once-through seawater cooling systems based on the J-ABWR design are:

- CW: App. 184,800 m^3/h
- TSW: App. 7,400 m^3/h
- RSW: App. 10,800 m^3/h

The impact that the increase in temperature might have on the receiving water is dependent on the nature of the receiving water and its flowrate and therefore will be assessed at site-specific stage. As a result, there is no assessment of thermal impact of the cooling water discharge undertaken as part of GDA.

The seawater inlet and outlet structures for the system will need to be sited and designed to reduce the potential for sediment mobilisation and scour on the sea bed, and to minimise the impact on surrounding habitats and species. These factors are also site-specific and will be addressed at the site-specific permitting stage.

8.3.3. Fish Deterrent and Fish Return Systems

Large water intakes such as those required on power station seawater cooling systems can entrain, or impinge upon inlet screens, fish and other marine organisms (which may be killed or suffer physical damage as a result).

Fish entrainment and impingement is a highly complex matter that varies with locality, and depends on the interplay of numerous factors, including the chemical and physical nature of the water body, the intake requirements of the facility, climatic conditions, and biology of the local area. A number of techniques have been developed and applied by industry to prevent or reduce the entrainment and impingement of fish in large cooling water inlets, and reduce their mortality. The relevant European level guidance (details of which can be found in [Ref-13] in section 4.5) notes that the optimum solution must be evaluated on a site-specific basis, and further states that no particular techniques to deter and/or protect fish can yet be identified as BAT.

As the design of any fish deterrent/protection scheme will depend on site-specific factors, it is not possible to define a specific scheme design at the GDA stage; detailed design of specific schemes will be considered at site-specific permitting stage. It can be stated however, that there are various technology options to minimise the impact of the inlet system on fish and other marine organism entrainment/impingement and there is no reason why the right option or combination of options could not be identified for any particular coastal site in England or Wales. Measures that may be adopted as part of the system to minimise fish impingement and entrainment include (further details of these options can be found in [Ref-13], section 4.5):

- Design of the inlet structure to minimise intake velocities.
- Location of the inlet structure.
- Use of screens and fish return systems.

- Physical barriers.
- Behavioural barriers.

8.3.4. Water Discharge

There will be a number of waste water discharges from the UK ABWR for which an Environmental Permit will be required at the site-specific stage. Within section 5 of [Ref-13], the processes by which these waste streams arise and are managed is described, along with (where possible) the means by which they will be discharged and their impact on the environment minimised. However, some aspects of the means by which potential impacts will be minimised are dependent on the particular aspects of the local environment, and as such can only be addressed at site-specific stage.

The main potential impacts of the water discharges can be categorised as:

- Impact of thermal discharges, i.e. impact of cooling water return, and;
- Impact of chemicals within the cooling water and site drainage system discharges.

The impact of the cooling water return from the UK ABWR, in terms of how the increase in temperature might affect the biology of the receiving water, is entirely dependent on the nature of the receiving water and therefore will be assessed at site-specific stage; no assessment of thermal impact of the cooling water discharge has been undertaken for GDA.

There are potential uses for the considerable amount of waste heat that is discharged to the environment via the cooling water return; however, research has shown it is often difficult to make use of the waste heat in remote locations such as those at which nuclear power stations are sited in the UK. The options available for the potential use of waste heat are generally dependent on site location and other site-specific factors and thus will be reviewed again at the site-specific permitting stage.

Cooling water systems generally require some sort of chemical dosing to minimise the level of obstruction caused by scaling and bio-fouling. The choice of dosing for the main UK ABWR CW system will be heavily influenced by the nature of the receiving environment and therefore will be addressed at site-specific stage. In addition to chemical dosing, the CW system also employs a physical cleaning system to remove scales in each cooling tube of the condenser (cleaning balls and backwashing during operation of the plant). Both the TSW and RSW systems will be dosed with a ferric reagent to deposit an iron oxide layer on the tubing internals or chlorine to act as a biocide. The selection of chemical dosing depends on the type of heat exchanges used and potential biocide is shown for evaluating the effect to marine environment.. Two possible designs for the TCW and RCW heat exchangers are included at GDA stage. The discharges from these systems are mixed in a tank known as the Seal Pit before discharge to the sea.

The cooling water systems should not have any radioactive or non-radioactive contaminants present other than the dosing chemicals which will only be dosed at levels that should not cause harm to the receiving environment; future operators will undertake monitoring at the Seal Pit to ensure the waters being discharged meet the relevant criteria/thresholds determined for a specific site.

Effluent streams also arise from the UK ABWR drainage systems. The main drainage systems are as follows (these are described further in section 5.3.2 to 5.3.6 of [Ref-13]):

- Service water storm drain (SWSD);
- Non-radioactive storm drain (NSD);
- CAD;
- HCW;
- LD;
- LCW - Component liquid waste drain and the floor liquid drain;

- Boiler emptying (or 'blowdown');
- Purified Water Treatment Facility (PWTF) effluent;
- Site rainwater drainage.

The NSD and SWSD stream capture liquid effluent from non-controlled areas of the site, and should therefore have zero radioactive contamination. The CAD, HCW, LD and LCW drainage streams arise from controlled areas of the site and may therefore have radioactive contaminants present, although the CAD system should be essentially free from radiological contamination. These drainage streams make up the UK ABWR's LWMS (summarised in section 8.1.2.2 of this document).

The location of the auxiliary boilers and the PWTF plant outside the inner fence means that the liquid effluent generated (boiler blowdown and PWTF purification effluent respectively) cannot be discharged directly from these two facilities to the Seal Pit. The effluent will therefore be transferred in batches from these facilities to the Seal Pit.

Discharges to sea occur from the SWSD, NSD, HCW, LD, CAD and rainwater drainage routes, as well as from the boiler blowdown and PWTF purification. However, as outlined in section 8.1.2.2 of this document, the design of the LWMS system (which includes the HCW, LD and CAD systems) enables liquid effluents to undergo repeated rounds of treatment within the LWMS, with the objective of re-using as much of the treated effluent as possible, as "clean" process water, rather than discharging all of it to the environment. This means that the majority of contaminants can be retained within the UK ABWR, and captured in solid waste streams, and releases to the environment are minimised.

For the minimal remaining discharges that are necessary, discharge criteria will be set at site-specific permitting stage depending upon the characteristics of the receiving waters. In section 5.3 of [Ref-13] some discharge criteria for a Japanese ABWR and returning criteria to the CST are presented to demonstrate the level of discharge control that can be achieved through the UK ABWR LWMS.

8.3.5. Combustion Plant

The UK ABWR will require a number of items of combustion plant for auxiliary steam production and to provide back-up electrical power in the event that there is an interruption to the grid supply. The combustion plant will require an Environmental Permit at the site-specific stage. For the purposes of the GDA it has been assumed that there will be no incineration plant at the generic site therefore no assessment of the impact of such plant has been carried out.

The typical combustion plant consists of the following:

- Three standby emergency diesel generators (EDGs), each with a rated thermal input of 18.0 MWTh and an output of 7.2 MWe; these are to be located individually in separate EDG buildings adjacent to the reactor building;
- Two standby diesel driven Backup Building generators (BBGs), each with a rated thermal input of 6.14 MWTh and an output of 2.4 MWe, located in the back-up building;
- Two auxiliary diesel-fired boilers, each with a rated thermal input of 24.1 MWTh, located in the boiler house building;
- One diverse additional generator (DAG) with a rated thermal input of 18.0 MWTh and an output of 7.2 MWe; the purpose of the DAG is to provide backup to a common cause failure of the EDGs and it has therefore been assumed for GDA that this unit will be similar to the EDGs themselves; however, the ultimate size, drive system, fuel type and location of the DAG is still under design; and,
- Two fire protection pumps, each with a rated thermal input of <3 MWTh; the fire protection pumps are located together in a single building and are considered trivial for the purposes of assessing the combustion activity for GDA (see below).

It is assumed at GDA stage that all the above will be operated using diesel fuel oil. Of the above listed plant, only the auxiliary boilers will operate for any significant period; it is expected that during the winter months, both boilers may operate and during summer just one will operate, and probably at reduced load. The other items of plant are all back-up/emergency plant and the only times they will be expected to be operated during normal operations will be as a once-off at commissioning and thereafter for a short period regular testing purposes (estimated to be about one hour each month and less than three hours each 18 months).

The main environmental impacts of combustion plant are associated with the combustion gases, with sulphur dioxide and nitrogen dioxide being the specific gases generally considered to be the most hazardous to health. Carbon monoxide and particulate matter are also produced. The specific plant that will be used in the UK stations has not yet been decided – it will be up to future operators to decide which make and manufacture of plant they wish to use. However, it is possible to make some assessment of the potential impacts by considering emissions from typical plant that are considered to represent BAT at the present time during GDA; thus typical emissions data has been used to undertake some preliminary assessments of the potential air quality impacts of the UK ABWR combustion plant.

In terms of sulphur dioxide, it is expected that emissions from the combustion installation at the UK ABWR site will be controlled via the primary technique of fuel selection, where it has been assumed that UK specification ultra-low sulphur diesel (ULSD) will be used (0.001% sulphur by weight, in accordance with BS EN 590). The impacts of sulphur dioxide from plant running on this fuel are generally considered negligible. Nitrogen dioxide however cannot be controlled so easily and it is the emissions of this gas (and precursors of it) which are the main impact with combustion plant.

An evaluation of the potential impact of the combustion gas emissions on ground level receptors has been undertaken in two assessments:

- a screening assessment of the main process emissions (NO_x, CO, particulate matter and SO_2) using the Environment Agency's Horizontal Guidance Document H1 methodology, and;
- a more detailed screening assessment, using the USEPA's regulatory atmospheric dispersion model AEROMOD, of the short term NO_x emissions from the diesel generators.

The H1 assessment did not screen out all emissions for the EDGs and BBGs for short-term impacts (which are of most relevance to the assessment for the diesel generators given their function as backup/emergency plant only), nor all emissions for the auxiliary boilers for both long and short-term impacts. However, the H1 assessment technique is highly conservative and ignores dispersion factors such as plume buoyancy, and was therefore always likely to deliver a significant over-estimate of the potential impact. The AERMOD assessment was subsequently undertaken to investigate (in particular) the H1 predicted high short-term NO_x impact (as NO_2 at ground level) from the diesel generators. The more detailed AERMOD assessment method highlighted the over-estimate from the H1 methodology and demonstrated that a significant short-term impact from NO_x emissions from the EDGs and BBGs was unlikely (with appropriate dispersion through a discharge stack).

The results of the AERMOD assessment indicated that for the EDGs, discharge stack heights of 20-30 m above ground level (about 5-15m above the EDG buildings' roof heights) would result in a ground level concentration of NO_2 at the site boundary at a level approximately equivalent to the environmental assessment level (EAL) for NO_2 (200 $\mu g/m^3$), which is considered to be an acceptable level for the purposes of GDA. For the BBGs, a discharge stack height of 26.2 m above ground level (3m above the building roof height) would result in a ground level concentration of NO_2 at the site boundary at a level below the EAL; similarly, this is considered to be acceptable for the purposes of GDA.

The differences in the results obtained from the AERMOD assessment of short term NO_x emissions from the EDGs and BBGs, compared to those reported by the H1 assessment, highlighted the extremely conservative nature of the H1 assessment methodology. On this basis it has been concluded that all the pollutants modelled using the H1 assessment would be likely to result in ground level concentrations below the respective EALs when subjected to more detailed modelling.

It should be noted that a decision on the stack height required at an actual UK ABWR site would be made as part of the relevant site-specific assessment process. This assessment would include detailed dispersion modelling accounting for site topography, final building layout, final commissioning and operating strategy for the combustion plant, background ambient concentrations and a full set of meteorological data (typically five years' worth from an appropriate nearby location). As a consequence of the more detailed assessment that would be undertaken at site specific stage, the stack height selected for an actual site is likely to differ from the indicative heights presented at GDA stage.

9. Post-GDA Work

The Forward Action Plan (FAP) presented in the Step 2 version of this GEP summary document contained the necessary forward work to complete the GEP submission; this work has now been completed. The GEP submission has now been developed to address all the requirements in the P&ID and provide the necessary information for the Environment Agency's Detailed Assessment.

In the course of developing the GEP, certain design or operating decisions have been identified which now fall beyond the scope of GDA and will be subject to further optimisation by future operators. These areas are highlighted within the specific relevant GEP reports, most notably the Demonstration of BAT document [Ref-10] and the Approach to Sampling & Monitoring document [Ref-11]. The initial arrangements for ensuring that these actions are communicated to any future operator following the conclusion of GDA are detailed in the QMP [Ref-4].

During Step 3 of GDA, Hitachi-GE has further developed a plan for the arrangements for transfer of information to potential future operators and is undertaking enhanced collaborative working with these parties. In Step 4, a process has been written to describe these transfer arrangements, which is applicable to both the PCSR and the GEP.

Appendix A: Mapping of P&ID Requirements against GEP Documents

Item	Information required (text taken directly from P&ID Table 1)	Included in GEP submission?	Where in the GEP: Document	Where in the GEP: Section	Further information source (i.e. C1a, PCSR Strategy)
1	**General information relating to the requesting party and the design.**				
	Include:				
	Brief details about the requesting party, including its experience of reactor design and plants in service.	Yes	E1: Summary of GEP Submission	5	C1a: Hitachi-GE UK ABWR Concept Design [Ref-16]
	A simple, outline description of the design including schematic diagrams.	Yes	E1: Summary of GEP Submission	6 6.1	ABWR General Description [Ref-19]
	A brief history of the design, identifying predecessor plant and the main design changes.	Yes	E1: Summary of GEP Submission	6	C2a: Genesis of ABWR design [Ref-17]
	Identification of discharge points to the environment for gaseous and aqueous radioactive wastes.	Yes	E1: Summary of GEP Submission	8.1.2	E7: Quantification of Discharges and Limits
	Description and characteristics of the generic site (or sites) that the requesting party will use to provide its dose assessment (see item 7 below). Any statement of acceptability we issue after our assessment will be on the basis of these characteristics. A range of generic sites might be chosen with coastal, estuarine and inland characteristics.	Yes	E1: Summary of GEP Submission	7.1	E2: Generic Site Description
	A summary of the proposed discharges of radioactive waste and their potential impact on members of the public and non-human species at the generic site.	Yes	E1: Summary of GEP Submission	8.2	E4: Radioactive Waste Management Arrangements E7: Quantification of Discharges and Limits E8: Prospective Dose Modelling
	A summary of the 'conventional' environmental impacts (see item 8 below) of the facility.	Yes	E1: Summary of GEP Submission	8.3	E9: Other Environmental Regulations

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	Section	
2	**A description of the requesting party's management arrangements and responsibilities for:**				
	Developing the design	No	-	-	Covered in the Hitachi-GE quality assurance arrangements for GDA, specifically in the Generic Design Development Control procedure [Ref-46].
	Managing the GDA project	No	-	-	Described in the QMP [Ref-4] and supporting procedure Communication, Reporting Lines and Distribution of Information in the GDA Organisation [Ref-47]
	Establishing the methodology for identifying the 'best available techniques' (BAT - see 4 below) and ensuring their use in the design	Yes	E3: Approach to Optimisation	Whole document	This methodology forms part of the Design Review Process and is described in Generic Design Development Control procedure [Ref-46].
	Producing and maintaining the submission	No	-	-	Described in the Document Control Manual [Ref-48] and delivered by the Master Document Submission List [Ref-49]

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	Section	
2	Ongoing communications with the regulators and responding to matters raised by them during GDA	No	-	-	This is addressed within the Interface Arrangements between Hitachi-GE and the Regulators [Ref-33]. Quality assurance arrangements have been developed to support the specific requirements.
	Maintaining records of design and construction	No	-	-	Described in the Generic Design Development Control procedure [Ref-46] and Control of General Documents and Records [Ref-50].
	Controlling and documenting design modifications, both during and after completion of GDA	No	-	-	Described in: the Design Development Control procedure [Ref-46]; Design Change Control and Documentation [Ref-51]; and, Definition of Design Reference Point [Ref-52]. Post-GDA, arrangements will be contractually defined with potential operators.
	Transferring information to potential operators and providing ongoing support to them throughout the reactor's lifecycle.	Yes	E1: Summary of GEP Submission	9	This information is summarised in section 7.1.1 and section 9 of this GEP Summary Document (E1). The approach is being considered by Hitachi-GE and potential site operators. A plan has been developed for the preparation of a procedure to define this during GDA Step 4.

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	Section	
3	**Detailed information relating to the design.**				
	Include:				
	A technical description of the facility's main plants, systems and processes, supported by process diagrams.	No	-	-	This information is provided in PCSR documentation, as referenced from E4: Radioactive Waste Management Arrangements.
	Identification of the plants, systems and processes which have a bearing on: - radioactive waste (solid, liquid and gaseous) generation, treatment, measurement, assessment and disposal - the conventional environmental impacts (see item 8 below) of the facility.	Yes	E4 (for radioactive waste) E9 (for conventional impacts)	Whole documents	This information is provided in PCSR documentation, as referenced from E4: Radioactive Waste Management Arrangements.

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	**Section**	
4	**A detailed description of the radioactive waste management arrangements.**				
	Include:				
	Identification of the strategic considerations with respect to radioactive waste management which underpin the design.	Yes	E4: Radioactive Waste Management Arrangements	Whole document	Integrated Waste Strategy [Ref-36], PCSR Chapter 18 Radioactive Waste Management and PCSR Chapter 31 Decommissioning.
	A description of how radioactive wastes and spent fuel will arise throughout the facility's lifecycle (including decommissioning) and your plans for how they will be managed and disposed of, to encompass:	Yes	E4: Radioactive Waste Management Arrangements	Whole document	Integrated Waste Strategy [Ref-36], PCSR Chapter 18 Radioactive Waste Management and PCSR Chapter 31 Decommissioning.
	- sources of radioactivity and matters which affect wastes arising	Yes	E4: Radioactive Waste Management Arrangements	Whole document	Integrated Waste Strategy [Ref-36], PCSR Chapter 18 Radioactive Waste Management and PCSR Chapter 31 Decommissioning.
	- gaseous, aqueous and other wastes.	Yes	E4: Radioactive Waste Management Arrangements	8 9 10.8 11	Integrated Waste Strategy [Ref-36], PCSR Chapter 18 Radioactive Waste Management and PCSR Chapter 31 Decommissioning.
	A description of how the production, discharge and disposal of radioactive waste will be managed to protect the environment and to optimise the protection of people.	Yes	E5: Demonstration of BAT E6: Approach to Sampling and Monitoring.	E5: Whole document E6: 8	The majority of the Claims, Arguments and Evidence are presented in E5. Claims, Arguments and Evidence concerning sampling and monitoring of discharges are provided in E6.

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	Section	
4	Describe the optimisation process used and identify and justify the proposed techniques you are proposing as BAT.	Yes	E3: Approach to Optimisation	Whole document	-
	In identifying techniques, address both the technology to be used and the way the facility is designed and will be built, maintained, operated and dismantled.	Yes	E5: Demonstration of BAT E6: Approach to Sampling and Monitoring.	E5: Whole document E6: 8	The majority of the Claims, Arguments and Evidence are presented in E5. Claims, Arguments and Evidence concerning sampling and monitoring of discharges are provided in E6. PCSR Chapter 31 Decommissioning provides more information on decommissioning.
	In justifying techniques as BAT, address the following, in respect of wastes arising throughout the lifetime of the facility:				
	- preventing and minimising (in terms of radioactivity) the creation of radioactive waste	Yes	E5: Demonstration of BAT	Section 5.1 (Claim 1)	Integrated Waste Strategy [Ref-36] and PCSR Chapter 18 Radioactive Waste Management.
	- minimising (in terms of radioactivity) discharges of gaseous and aqueous radioactive wastes	Yes	E5: Demonstration of BAT E6: Approach to Sampling and Monitoring.	E5: 5.2 (Claim 2) E6: 8	The majority of the Claims, Arguments and Evidence are presented in E5. Claims, Arguments and Evidence concerning sampling and monitoring of discharges are provided in E6.

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	Section	
4	- minimising the impact of those discharges on people, and adequately protecting other species	Yes	E5: Demonstration of BAT E6: Approach to Sampling and Monitoring.	E5: 5.5 (Claim 5) E6: 8	The majority of the Claims, Arguments and Evidence are presented in E5. Claims, Arguments and Evidence concerning sampling and monitoring of discharges are provided in E6.
	- minimising (in terms of mass/volume) solid and non-aqueous liquid radioactive wastes and spent fuel	Yes	E5: Demonstration of BAT	5.3 (Claim 3)	The majority of the Claims, Arguments and Evidence are presented in E5.
	- selecting optimal disposal routes (taking account of the waste hierarchy and the proximity principle) for those wastes	Yes	E5: Demonstration of BAT E4: Radioactive Waste Management Arrangements	E5: 5.4 (Claim 4) E4: 10	Integrated Waste Strategy [Ref-36] and PCSR Chapter 18 Radioactive Waste Management.
	- the suitability for disposal of any wastes and spent fuel for which there is no currently available disposal route and how they will be managed in the interim so as not to prejudice their ultimate disposal. [This should take account of the view of RWM (as the UK authoritative source in providing such advice) on the disposability of such wastes and spent fuel]	No	-	-	Hitachi-GE has obtained a view from the Nuclear Decommissioning Authority in the form of Disposability Assessments. This information is included in E4: Radioactive Waste Management Arrangements (through reference).

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP: Document	Where in the GEP: Section	Further information source (i.e. C1a, PCSR Strategy)
5	**Quantification of radioactive waste disposals**				
	Provide quantitative estimates for normal operation of:				
	Discharges of gaseous and aqueous radioactive wastes	Yes	E7: Quantification of Discharges and Limits	7.1 7.2	-
	Arisings of combustible waste and disposals by on-site or off-site incineration	Yes	E4: Radioactive Waste Management Arrangements	11.1 Appendix A	E5 Demonstration of BAT: 5.3.3
	Arisings of other radioactive wastes [by category and disposal route (if any)] and spent fuel	Yes	E4: Radioactive Waste Management Arrangements	11.1 Appendix A	Methodology for Expected Event Selection [Ref-53].
	For gaseous and aqueous radioactive wastes, you should estimate your monthly discharges:				
	On an individual radionuclide basis for significant radionuclides;	Yes	E7: Quantification of Discharges and Limits	7.1.1, 7.1.2 7.1.3 7.2.1	-
	On a group basis (for example 'total alpha' or 'total beta') for other radionuclides;	Yes	E7: Quantification of Discharges and Limits	7.1.1, 7.1.2 7.1.3 7.2.1	-

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	Section	
5	Via each discharge point and discharge route.	Yes	E7: Quantification of Discharges and Limits	7.1.1, 7.1.2 7.1.3 7.2.1	The radionuclide selection process is outlined in section 5 of E7.
	For combustible and other radioactive wastes, estimate the annual arisings and disposals during operation and give an indication of the likely arisings during decommissioning. Identify wastes in terms of their category (HLW, ILW, LLW, VLLW), physico-chemical characteristics and proposed disposal route (if any). Quantification should be in terms of activity of key individual radionuclides and overall groupings of radionuclides (for example, total beta), together with mass and / or volume.	Yes	E4: Radioactive Waste Management Arrangements	10.2 10.7 11 Appendix A	Hitachi-GE has obtained a view from the Nuclear Decommissioning Authority in the form of Disposability Assessments. This information is included in E4: Radioactive Waste Management Arrangements (through reference).
	Estimates of discharges and disposals should clearly show the contribution of each constituent aspect of normal operations, including: - routine operation (that is, typically, the design basis or "flowsheet design" and the minimum level of disposals); - start-up and shutdown; - maintenance and testing; infrequent but necessary aspects of operation, for example, plant wash-out; and the foreseeable, undesired deviations from planned operation (based on a fault analysis) consistent with the use of BAT, for example, occasional fuel pin failures.	Yes	E4: Radioactive Waste Management Arrangements E7: Quantification of Discharges and Limits	E4: 8 9 10 E7: 7	Calculation of Radioactive Waste End User Source Term Value [Ref-54] Topic Report on Discharge Assessment during Normal Operation [Ref-55]

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	Section	
5	Support your estimates with performance data from similar facilities and explain, where relevant, how changes in design or operation from those facilities affect the expected discharges and disposals. Demonstrate that discharges and waste arisings will not exceed those of comparable power stations across the world (as required by UK Government policy (GB Parliament, 2008)).	Yes	E5: Demonstration of BAT (solid) E7: Quantification of Discharges and Limits (liquid and gaseous)	E5: Whole document E7: 9.5	-
	Provide your proposed limits for:				
	- gaseous discharges	Yes	E7: Quantification of Discharges and Limits	9	-
	- aqueous discharges	Yes	E7: Quantification of Discharges and Limits	9	-
	- disposal of combustible waste by on-site incineration.	N/A	-	-	[N.B. no on-site incineration is assumed for the UK ABWR at GDA].
	Provide your proposals for annual site limits (on a rolling twelve months basis) for gaseous and aqueous discharges, and monthly limits for disposals by on-site incineration, and describe how these were derived. If desired, additionally propose limits to reflect an operating cycle, that is, 'campaign' limits.	Yes	E7: Quantification of Discharges and Limits	9	-

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP: Document	Where in the GEP: Section	Further information source (i.e. C1a, PCSR Strategy)
6	**A description of the sampling arrangements, techniques and systems for measurement and assessment of discharges and disposals of radioactive waste.**				
	Include:				
	- Details of in-process monitoring arrangements - Details of arrangements for monitoring final discharges of gaseous and aqueous wastes - Details of arrangements for monitoring disposals of non-aqueous liquid and solid wastes	Yes	E5: Demonstration of BAT (in-process) E6: Approach to Sampling and Monitoring (final discharges)	E5: 5.2.1, 5.2.3, 5.2.5 E6: 8	E4: Radioactive Waste Management Arrangements: section 11 Radioactive Solid Wastes Monitoring Requirements [Ref-56]
	A demonstration that the proposals represent the best available techniques for monitoring	Yes	E5: Demonstration of BAT (in-process) E6: Approach to Sampling and Monitoring (final discharges)	E5: 5.2.1, 5.2.3, 5.2.5 E6: 8	Radioactive Solid Wastes Monitoring Requirements [Ref-56]
	Confirmation that the sensitivity is sufficient to: - readily demonstrate compliance with the proposed limits - meet the levels of detection specified in reference EU, 2004	Yes	E6: Approach to Sampling and Monitoring	8	-
	A description of the facilities provided for independent periodic sampling (by the regulator) of final discharges of gaseous and aqueous wastes	Yes	E6: Approach to Sampling and Monitoring	9	-

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	Section	
7	**A prospective radiological assessment at the proposed limits for discharges and for any on-site incineration.**				
	Include:				
	Annual dose to most exposed members of the public for liquid discharges.	Yes	E8: Prospective Dose Modelling	8	-
	Annual dose to most exposed members of the public for gaseous discharges (identifying separately the dose associated with on-site incineration where applicable).	Yes	E8: Prospective Dose Modelling	8	-
	Annual dose to the most exposed members of the public for all discharges from the facility.	Yes	E8: Prospective Dose Modelling	8	-
	Annual dose from direct radiation to the most exposed member of the public.	Yes	E8: Prospective Dose Modelling	7	-
	Annual dose to the representative person for the facility.	Yes	E8: Prospective Dose Modelling	9	-
	Potential short-term doses, including via the food chain, based on the maximum anticipated short-term discharges from the facility in normal operation.	Yes	E8: Prospective Dose Modelling	10	-
	A comparison of the calculated doses with the relevant dose constraints.	Yes	E8: Prospective Dose Modelling	11	-

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	Section	
7	An assessment of whether the build-up of radionuclides in the local environment of the facility, based on the anticipated lifetime discharges, might have the potential to prejudice legitimate users or uses of the land or sea.	Yes	E8: Prospective Dose Modelling	12	-
	Collective dose truncated at 500 years to the UK, European and world populations.	Yes	E8: Prospective Dose Modelling	13	-
	Dose-rate to non-human species.	Yes	E8: Prospective Dose Modelling	14	-
	State which models were used to calculate these doses and why they are appropriate, and set out all the data and assumptions (with reasoning) used as input to the models.	Yes	E8: Prospective Dose Modelling E2: Generic Site Description	E8: 5 6 16 E2: Whole document	-

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	Section	
8	**Information relating to other environmental regulations**				
	Water use and abstraction				
	Provide details and estimates of fresh water requirements for the design.	Yes	E9: Other Environmental Regulations	4.1 4.3	-
	Provide details and estimates of cooling water requirements for the design relevant to the generic site. Include consideration of:	Yes	E9: Other Environmental Regulations	4.1 4.4	-
	- seawater or river water abstraction	Yes	E9: Other Environmental Regulations	4.4.1	-
	- use of conventional cooling towers or hybrid cooling towers	Yes	E9: Other Environmental Regulations	4.4.1	-
	- abstraction inlet fish deterrent schemes	Yes	E9: Other Environmental Regulations	4.1 4.5	-
	- fish return systems.	Yes	E9: Other Environmental Regulations	4.1 4.5	-

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	Section	
8	***Discharges to surface waters***				
	Provide a description of how aqueous waste streams will arise, be managed and be disposed of throughout the facility's lifecycle. Include:				
	- sources and quantities of contaminants (including disinfectant and biocides), highlighting any priority substances (as specified in the 'Priority Substances' Directive (EU, 2008))	Yes	E9: Other Environmental Regulations	5.1 5.3	PCSR Chapter 18 Radioactive Waste Management (sub-chapter 18.2).
	- identification of the effluent and surface water runoff streams contributing to the overall discharge and how they are controlled	Yes	E9: Other Environmental Regulations	5.1 5.4	-
	- potential options and associated environmental impact for disposal of each individual effluent stream	Yes	E9: Other Environmental Regulations	5.1 5.4	-
	- the means of control in the event of detection of unplanned radioactive or other contamination of the discharge	Yes	E9: Other Environmental Regulations	5.1 5.4	-
	- options for beneficial use of the waste heat produced	Yes	E9: Other Environmental Regulations	5.1 5.5	-
	- environmental impact of thermal discharges.	Yes	E9: Other Environmental Regulations	5.1.1	-

Item	Information required (text taken directly from P&ID Table 1)	Included in core GEP documents?	Where in the GEP		Further information source (i.e. C1a, PCSR Strategy)
			Document	Section	
8	***Discharges to groundwater***				
	If there will be discharges to groundwater, describe the nature and quantity of those discharges and provide an assessment of the impact on groundwater.	Yes	E9: Other Environmental Regulations	6.3	-
	Operation of installations (combustion plant and incinerators)				
	Identify what combustion plant (for example, for standby generation or auxiliary boilers) will be provided.	Yes	E9: Other Environmental Regulations	7.2 7.4 7.5	-
	- If the aggregate rated thermal input of all combustion plant is greater than 50 MW, provide a comparison of the proposed technology against our sector guidance.	Yes	E9: Other Environmental Regulations	7.2 7.6	-
	- If the aggregate rated thermal input of all combustion plant is greater than 20 MW, describe how greenhouse gas emissions will be monitored.	Yes	E9: Other Environmental Regulations	7.2 7.8	-
	If the design includes an on-site incinerator with a capacity or 1 tonne or more per hour, provide a comparison of the proposed technology against our sector guidance.	Yes	E9: Other Environmental Regulations	7.2	-
	Substances subject to the Control of Major Accident Hazards Regulations				
	Identify any need for on-site storage of substances above the qualifying thresholds in COMAH15. If a threshold is exceeded, describe the measures taken in the design to prevent a major accident to the environment.	Yes	E9: Other Environmental Regulations	8	-
	Fluorinated greenhouse gases and ozone-depleting substances				
	Identify whether any equipment included in the design will contain fluorinated greenhouse gases or ozone-depleting substances (as defined in EU, 2014 and EU, 2009, respectively). If so, describe the measures taken in the design to prevent and minimise leakage of such substances.	Yes	E9: Other Environmental Regulations	9	-

Appendix C: Document Maps

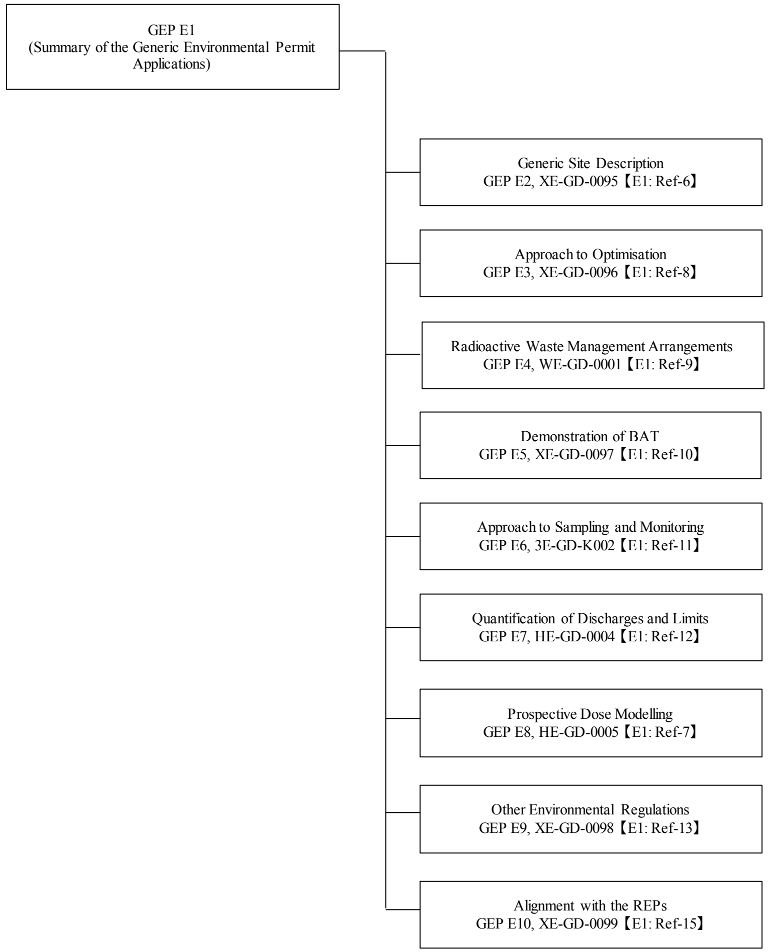


Figure C-1: Document Map of E1

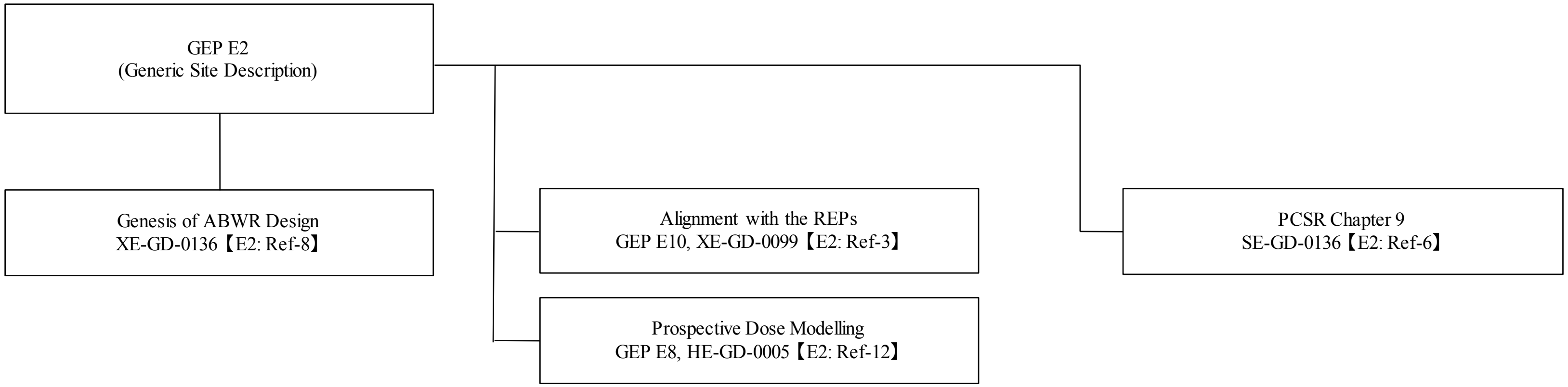


Figure C-2: Document Map of E2

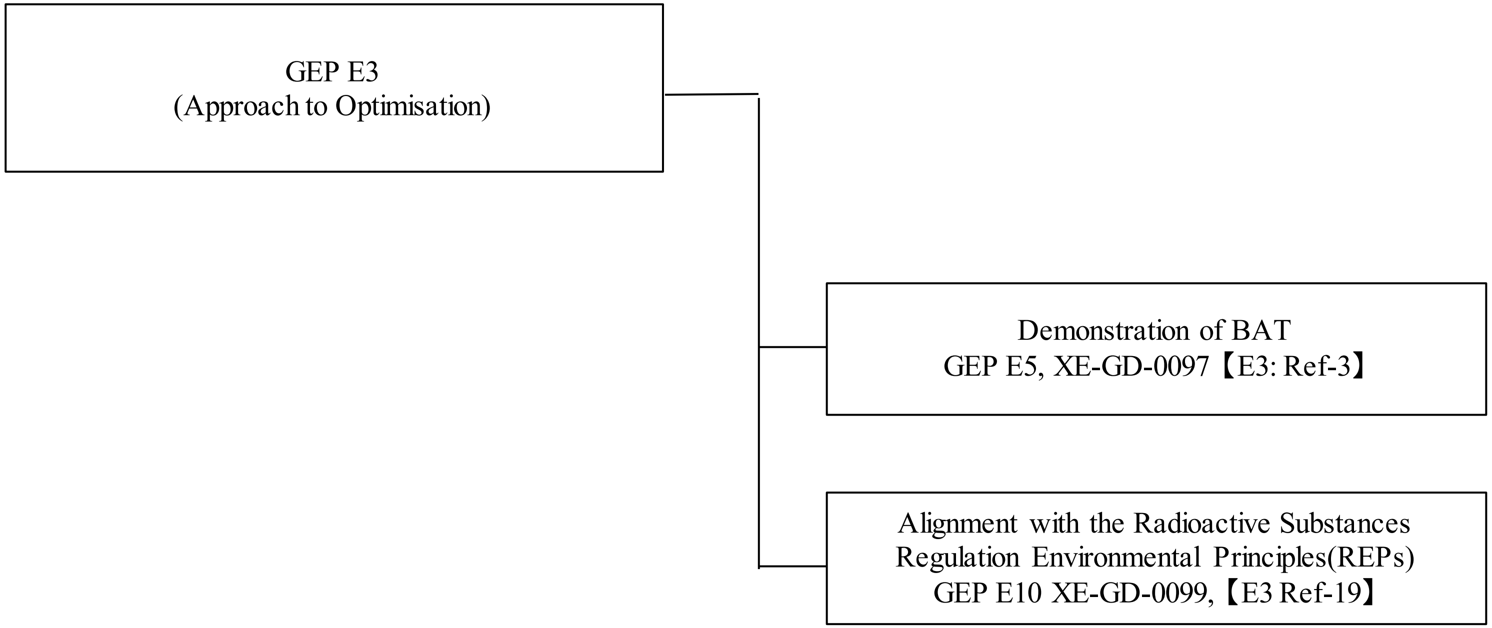


Figure C-3: Document Map of E3

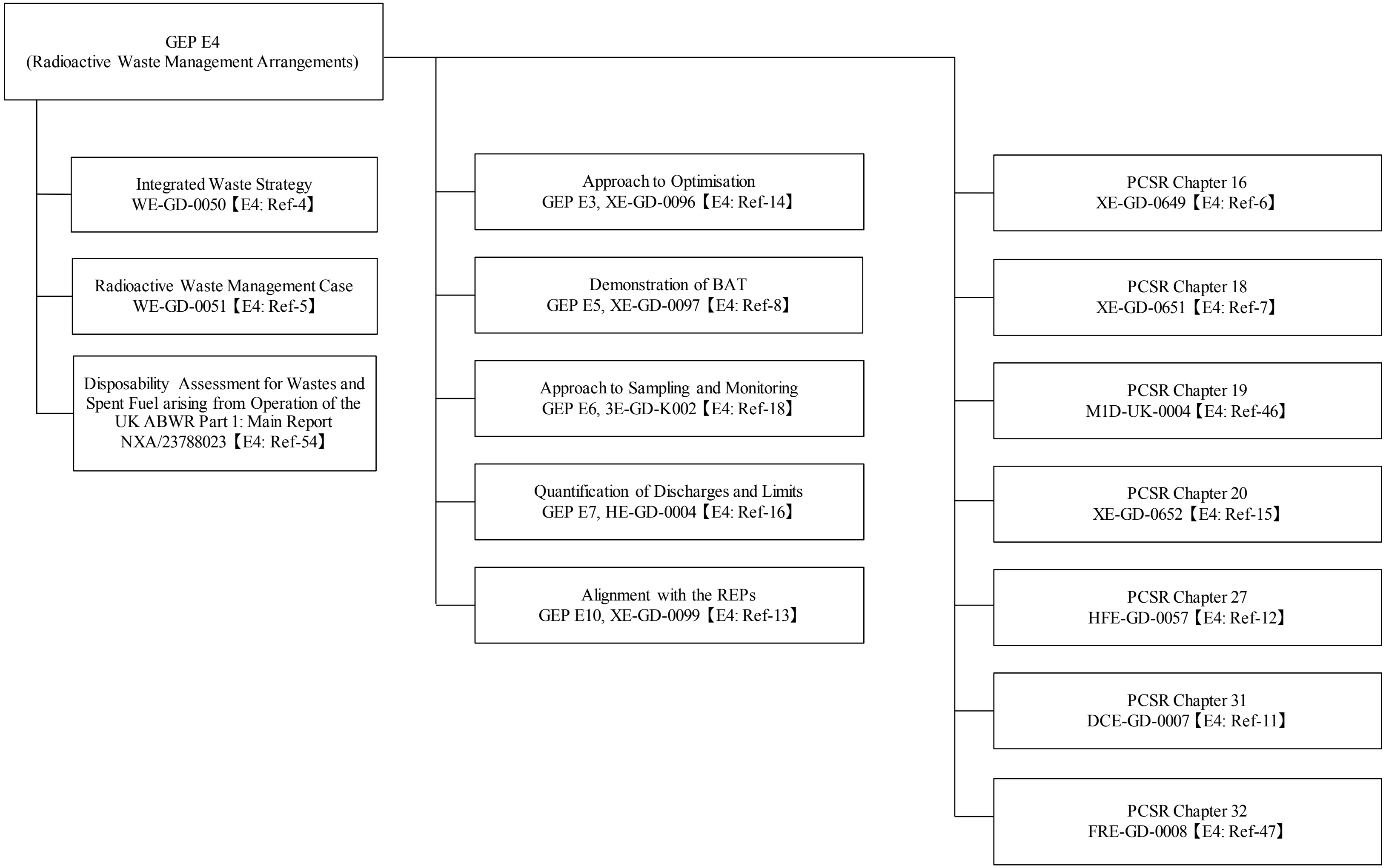


Figure C-4: Document Map of E4

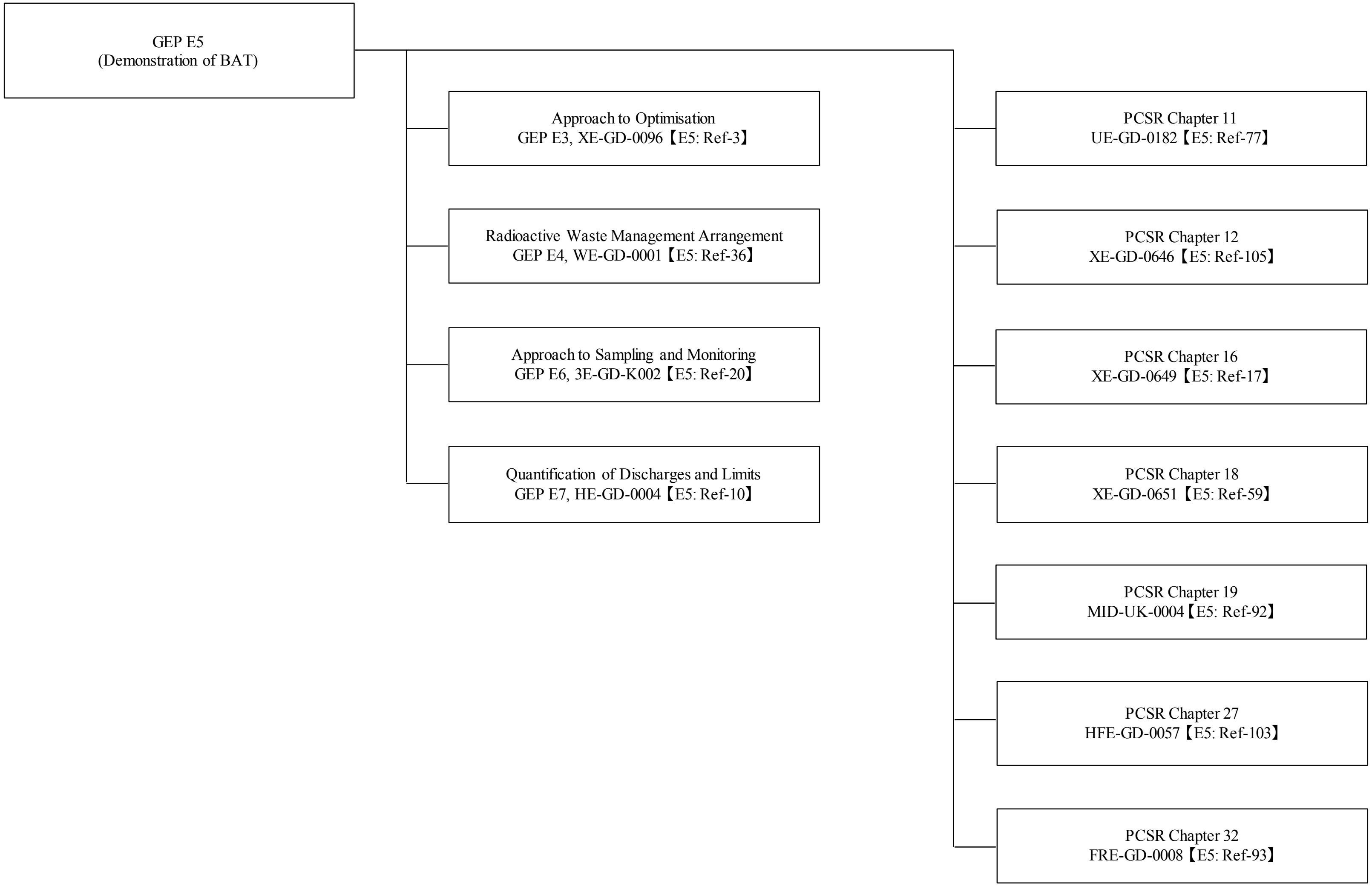


Figure C-5: Document Map of E5

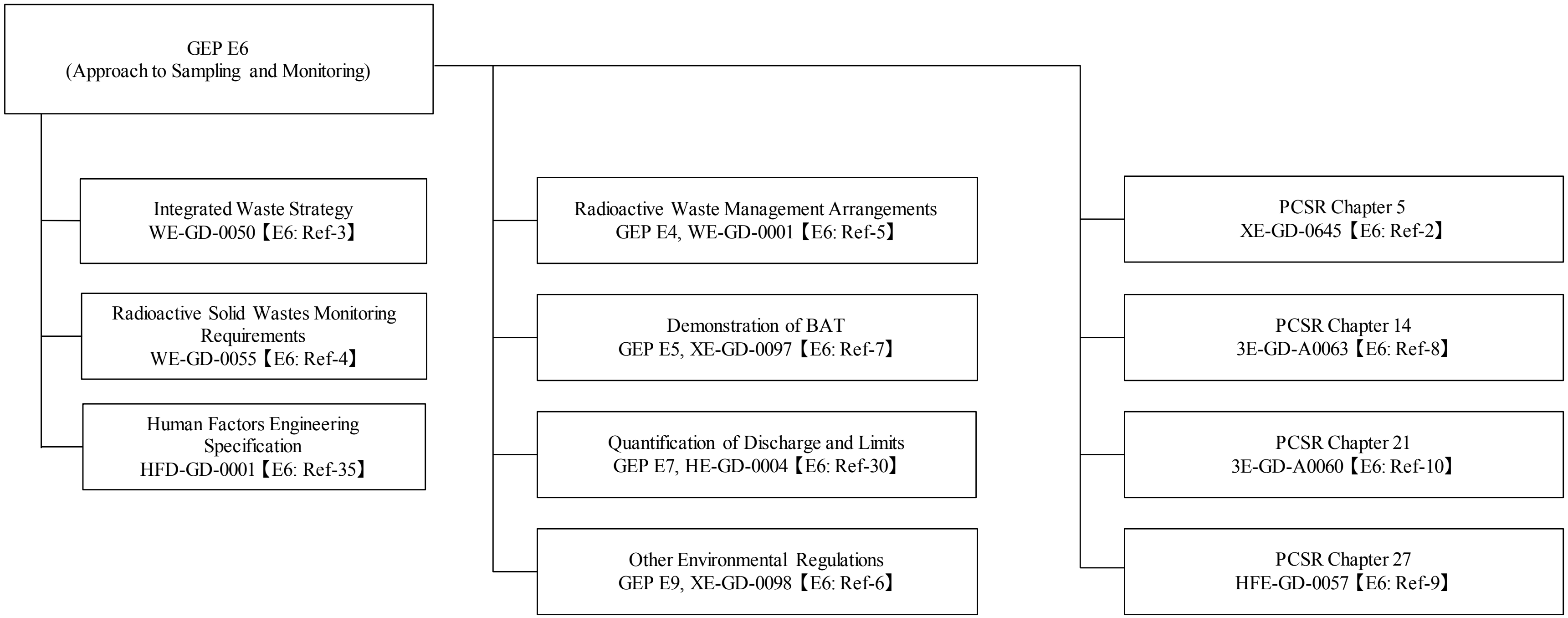


Figure C-6: Document Map of E6

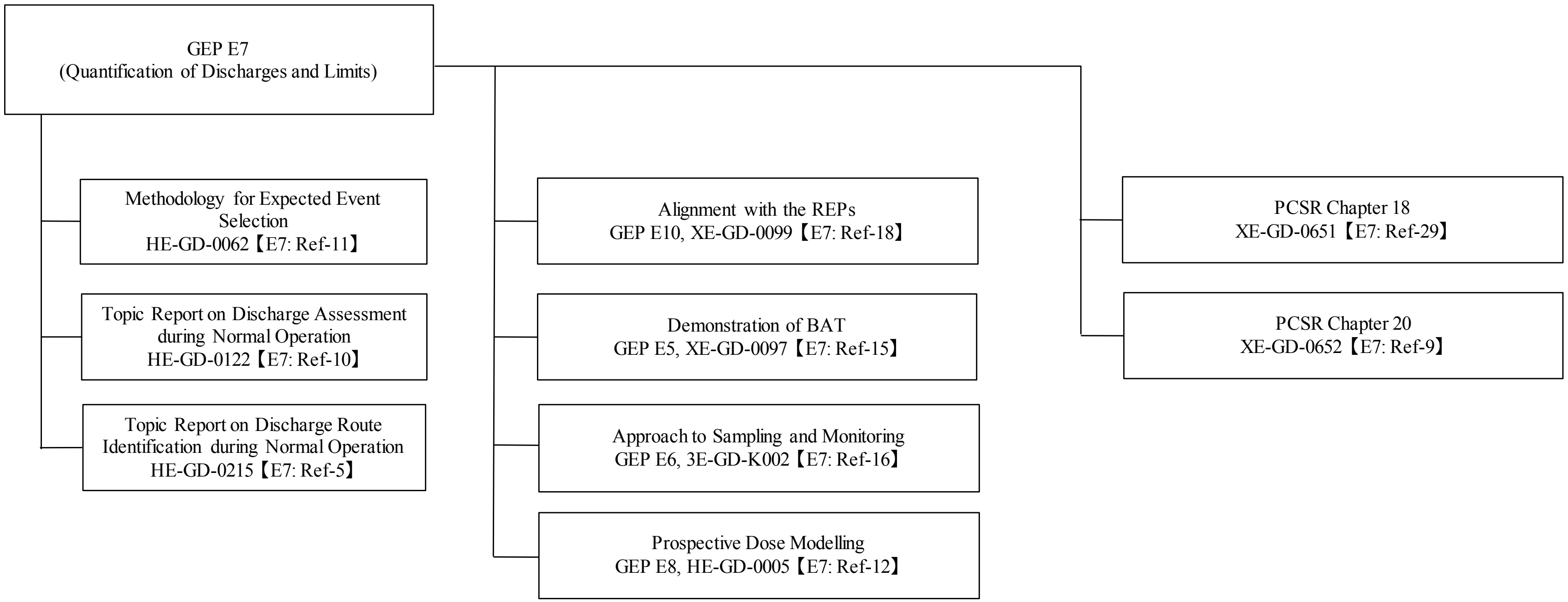


Figure C-7: Document Map of E7

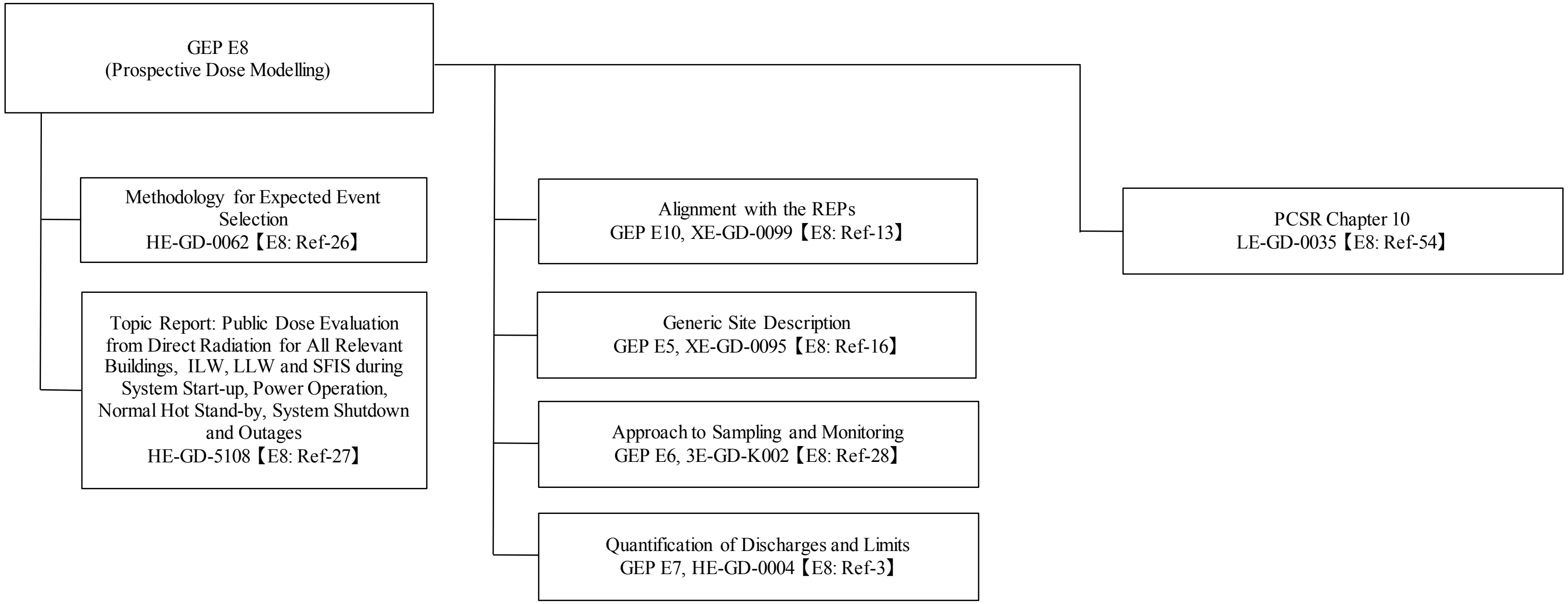


Figure C-8: Document Map of E8

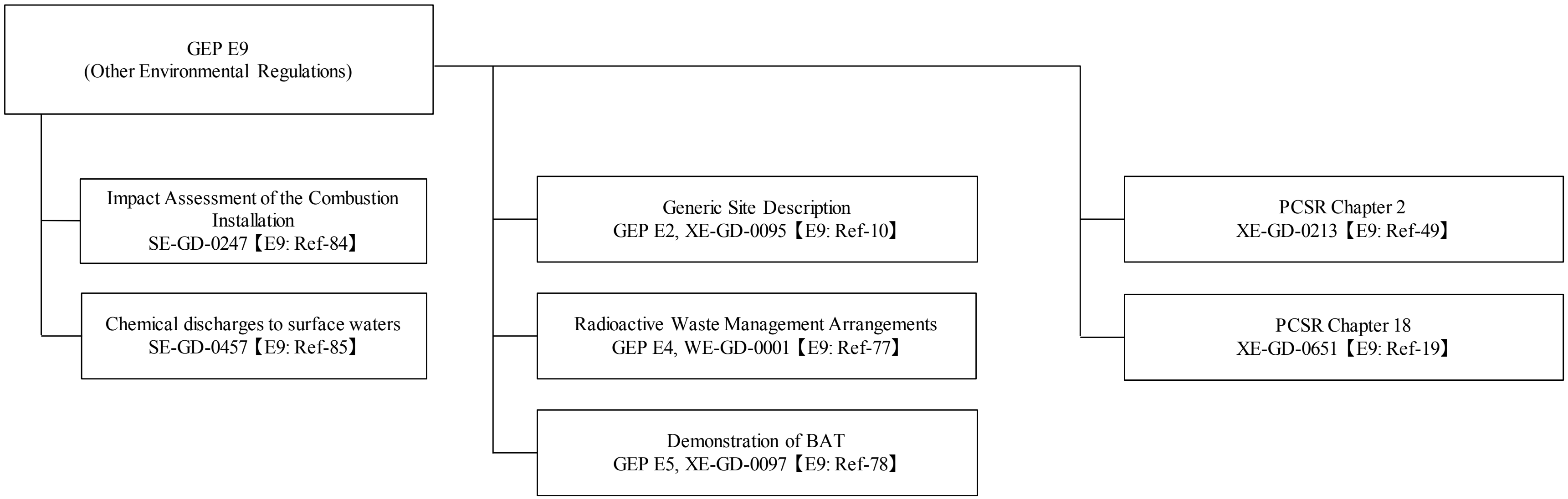


Figure C-9: Document Map of E9

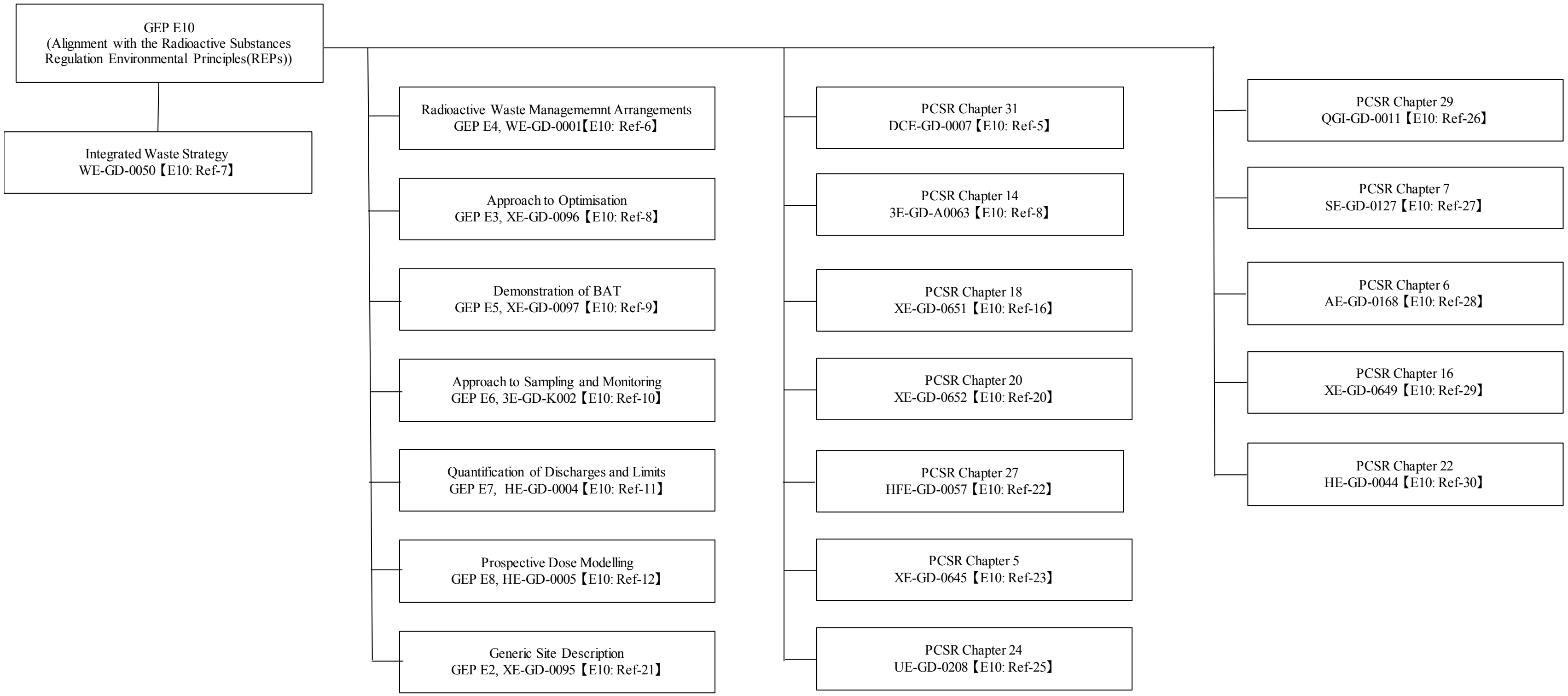


Figure C-10: Document Map of E10