GE Hitachi Nuclear Energy

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BWRX-300 UK Generic Design Assessment (GDA) Chapter E8 - Approach to Sampling and Monitoring

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EXECUTIVE SUMMARY

The GEH BWRX-300 is a Boiling Water Reactor (BWR) that is designed as a Small Modular Reactor. The tenth generation BWRX-300 design incorporates the lessons learned from worldwide programmes and the operating experience/programmes of several BWRs, most notably the Economic Simplified Boiling Water Reactor and the Advanced Boiling Water Reactor.

The BWRX-300 design has focused on:

- Preventing/eliminating the generation of radioactive waste;
- Where the generation of radioactive waste cannot be avoided, then minimising the generation of that waste (activity and volume); and
- Treating/abating any radioactive waste generated so that it is concentrated/contained or minimised before release to the environment.

GEH are, as the Requesting Party, presenting an environment case submission to the United Kingdom (UK) regulators for a Generic Design Assessment (GDA) at the Step 2 level for the BWRX-300.

This document is a chapter within the Preliminary Environmental Report and is one of the documents that makes up the environment case. This chapter describes, at a high level, the following aspects relating to the sampling, measurement, and monitoring regime that will be included in the UK BWRX-300 design:

- Identification, under normal operating conditions, of all proposed authorised radioactive gaseous and aqueous liquid discharges;
- Arrangements for how discharges to the environment are to be monitored, measured, or sampled, as appropriate;
- Arrangements for characterisation of wet solid and dry solid radioactive wastes;
- Arrangements for any in-process monitoring, measurement, and sampling systems that will be employed; and
- Identification of the arrangements for where and how provision is to be made for any independent monitoring, measurement, and/or sampling.

The Best Available Techniques claims and arguments case for sampling and monitoring is also demonstrated within this report to the GDA Step 2 level.

This chapter presents a level of detail commensurate with a two-step GDA. A Forward Action Plan (FAP), with respect to the sampling and monitoring capabilities of the BWRX-300, is presented in Appendix A. The FAP defines the scope and timing of additional work required within GDA Step 2 and during future development phases.

GEH considers that the contents of this chapter meet the requirements for Step 2 of the GDA.

ACRONYMS AND ABBREVIATIONS

Acronym	Explanation
ABWR	Advanced Boiling Water Reactor
AHU	Air Handling Unit
ALARP	As Low As Reasonably Practicable
ARM	Area Radiation Monitoring Subsystem
BAT	Best Available Techniques
BS	British Standard
BWR	Boiling Water Reactor
CB	Control Building
CEAP	Continuous Exhaust Air Plenum
CFD	Condensate Filters and Demineralisers System
CFS	Condensate and Feedwater Heating System
CMon	Containment Monitoring Subsystem
CP	Corrosion Product
CR	Control Room
CRD	Control Rod Drive System
CREEFU	Control Room Emergency Envelope Filter Units
CST	Condensate Storage Tank
CUW	Reactor Water Cleanup System
CWS	Circulating Water System
DBR	Design Basis Record
DCIS	Distributed Control and Information System
DL	Defence Line
EA	Environment Agency
EFS	Equipment and Floor Drains System
ENDP	Engineering Developed Principle
EPF	Environment Protection Function
EPR	Environmental Permitting Regulations
EPRI	Electrical Power Research Institute
ESBWR	Economic Simplified Boiling Water Reactor
EUST	End User Source Term
FAP	Forward Action Plan
FP	Fission Product
FPC	Fuel Pool Cooling and Cleanup System
FSF	Fundamental Safety Function
FW	Feedwater
GDA	Generic Design Assessment

Acronym	Explanation
GEH	GE Hitachi Nuclear Energy
GW	Groundwater
HVS	Heating, Ventilation and Cooling System
HX	Heat Exchanger
IC	Isolation Condenser
ICC	Isolation Condenser Pools Cooling and Cleanup System
ILW	Intermediate Level waste
ISO	International Organization for Standardization
LWM	Liquid Waste Management System
MCA	Main Condenser and Auxiliaries
MCERTS	Monitoring Certification Scheme
MIC	Minimum Inhibitory Concentration
NHS	Normal Heat Sink
NRW	Natural Resources Wales
OGS	Offgas System
OPEX	Operational Experience
PCER	Pre-Construction Environmental Report
PCSR	Pre-Construction Safety Report
PCW	Plant Cooling Water System
PER	Preliminary Environmental Report
PING	Particulates, Iodine and Noble Gases
PREMS	Process Radiation and Environmental Monitoring System
PRM	Process Radiation Monitoring Subsystem
PS	Process Sampling Subsystem
PVS	Plant Vent Stack
RB	Reactor Building
RIFE	Radioactivity in Food and the Environment
RO	Reverse Osmosis
RP	Requesting Party
RSMDP	Radioactive Substances Management Developed Principle
RSR	Radioactive Substances Regulation
RWB	Radwaste Building
RWMA	Radioactive Waste Management Arrangements
RWST	Refueling Water Storage Tank
SCR	Secondary Control Room
SDC	Shutdown Cooling System
SDD	System Design Description

Acronym	Explanation
SSC	Structures, Systems, and Components
SWM	Solid Waste Management System
TB	Turbine Building
TOC	Total Organic Carbon
UK	United Kingdom
UK ABWR	UK Advanced Boiling Water Reactor
U.S.	United States
WGC	Water, Gas, and Chemical Pads

SYMBOLS AND DEFINITIONS

Symbol	Definition
Bq	Becquerels
Bq/m^3	Becquerels per cubic metre
Bq/y	Becquerels per year
µGy	Micrograys per hour
µSv/y	Microsieverts per year
MWe	Megawatt electrical

Term	Definition
D11	Process Radiation and Environmental Monitoring System (PREMS)
K30	Offgas System (OGS)
N71	Circulating Water System (CWS)
P40	Plant Cooling Water System (PCW)
W24	Normal Heat Sink (NHS)

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Revision #	Section Modified	Revision Summary
A	All	Initial Issuance

8. APPROACH TO SAMPLING AND MONITORING

Purpose

The GEH BWRX-300 is a Boiling Water Reactor (BWR) that is designed as a Small Modular Reactor (SMR).

The tenth generation BWRX-300 design incorporates the lessons learned from worldwide programmes and the Operational Experience (OPEX)/programmes of several GEH BWRs, most notably the Economic Simplified Boiling Water Reactor (ESBWR) and the Advanced Boiling Water Reactor (ABWR). The BWRX-300 design process builds on this extensive OPEX to mitigate nuclear design and construction risk. OPEX sources for the BWRX-300 project include the Institute of Nuclear Power Operations, the Electrical Power Research Institute's (EPRI's) Materials Reliability Program documents and Utility Requirements Document, and other regulatory guidance issued by the United States (U.S.) Nuclear Regulatory Commission and U.S. Department of Energy (DOE). Construction experience and improved construction methods from previous large projects are used to improve the quality and efficiency of the construction effort (GEH System Design Description (SDD) document 006N7781, "BWRX-300 Heating, Ventilation, and Cooling System" (HVS) (Reference 8-1)).

The BWRX-300 design has focused on:

- Preventing/eliminating the generation of radioactive waste
- Where the generation of radioactive waste cannot be avoided, then minimising the generation of that waste (activity and volume)
- Treating/abating any radioactive waste generated so that it is concentrated/contained or minimised before release to the environment

GEH is, as the Requesting Party (RP), presenting an environment case submission to the United Kingdom (UK) regulators for a Generic Design Assessment (GDA) at the Step 2 level for the BWRX-300. It should be noted that after completion of Step 2, GEH intend to proceed directly to site licensing rather than firstly completing Step 3 as an intermediate stage. This document is a chapter within the Preliminary Environmental Report (PER) and is one of the documents that makes up the environment case.

The purpose of this document is to describe the sampling and monitoring of gaseous and aqueous radioactive wastes, and characterisation of solid radioactive wastes, arising during normal operation of the BWRX-300. The sampling and monitoring regime is a fundamental function whilst radioactive wastes are being discharged or disposed of, as a means of obtaining characterisation data for these wastes. The characterisation of wastes provides information to support process control and, in the case of solid wastes, assurance of compliance with requirements for processing, storage, transport, and disposal of the waste. The use of characterisation data supports compliance with defined specifications such as nuclear site licence conditions, environmental permit conditions, and acceptance criteria for off-site treatment and/or disposal of solid wastes.

Scope

This chapter presents the following aspects relating to the sampling, measurement, and monitoring regime that will be included in the UK BWRX-300 design:

- Identification, under normal operating conditions, of all proposed authorised radioactive gaseous and aqueous liquid discharges
- Arrangements for how discharges to the environment are to be monitored, measured, or sampled, as appropriate
- Arrangements for characterisation of wet solid and dry solid radioactive wastes

- Arrangements for any in-process monitoring, measurement, and sampling systems that will be employed
- Identification of the arrangements for where and how provision is to be made for any independent monitoring, measurement, and/or sampling

Relevant legislation, regulatory requirements, and guidance are outlined in subsequent sections of this document. GEH recognises that all systems are required to demonstrate application of Best Available Techniques (BAT) for permitting, to demonstrate that optimisation to the As Low As Reasonably Achievable (ALARA) requirements of “The Environmental Permitting (England and Wales) Regulations 2016” (as amended) (EPR16) (Reference 8-2) are fulfilled by the BWRX-300 design. At GDA Step 2, only claims and arguments for application of BAT are presented. The methodology of how BAT will be demonstrated for the BWRX-300 are described in NEDC-34223P, “PER Ch. E6: Demonstration of Best Available Techniques Approach” (Reference 8-3). BAT claims and arguments relating specifically to sampling and monitoring arrangements are presented in Section 8.5 of this document.

It should be noted that there will be a considerable time lag between submission of a Step 2 GDA document and the actual operation of a GEH BWRX-300 reactor. Therefore, it is not appropriate to specify actual instrumentation at this time. In addition, as no formal site is adopted at this stage then no Groundwater (GW) boreholes or environmental monitoring programme can be finalised.

On this basis, this chapter will not:

- Provide precise locations of any monitoring, measuring, sampling, or characterisation equipment
- Identify actual instrumentation that will be used for monitoring, measuring, and/or sampling
- Identify any GW sampling requirements (except for acknowledging the likely requirement in the future)
- Identify any environmental monitoring programme
- Provide any evidence of BAT. Any BAT discussion will be limited to claims and arguments
- The data to be provided will be based upon already existing data from:
  - GEH design information on the BWRX-300
  - The UK ABWR design
  - The ESBWR design

The most appropriate sources of data are used and referenced. Appropriate adjustments and justifications will be provided where necessary.

The following key assumptions about the BWRX-300 have been made:

- The BWRX-300 is a single unit of 300 MWe capacity
- The generic site is on the coast
- There is no on-site incinerator
- There is no on-site laundry
- Welfare facilities are located outside of the power block
- The operating cycle is 12 months

- The outage period is 10 to 20 days[1]
- The top of the Plant Vent Stack (PVS) is 35 m above ground level

This chapter presents a level of detail commensurate with a two-step GDA. A Forward Action Plan (FAP) is presented in Appendix A, which defines the scope and timing of additional work beyond GDA Step 2. Specific commitments and actions that have been identified for completion during GDA Step 2 are presented in NEDC-34274P, "BWRX-300 UK GDA – Forward Action Plan" (Reference 8-4).

Document Structure

Following this introductory section, the document is structured in the following manner:

Section 8.1 Regulatory Context

Section 8.2 Parameters to be Measured (Final Discharges)

Section 8.3 Safety Categorisation and Classification

Section 8.4 System and Equipment Design

Section 8.5 Demonstration of BAT (Claims and Arguments)

Section 8.6 Independent Sampling

Section 8.7 References

Appendix A Sampling and Monitoring Forward Action Plan

Chapter Interfaces

This chapter interfaces with the following chapters within the PER:

- NEDC-34221P, "PER Ch. E4: Information about the Design" (Reference 8-5)
- NEDC-34222P, "PER Ch. E5: Radioactive Waste Management Arrangements" (Reference-8-6)
- NEDC-34223P, "PER Ch. E6: Demonstration of Best Available Techniques Approach" (Reference 8-3)
- NEDC-34224P, "PER Ch. E7: Radioactive Discharges" (Reference 8-7)
- NEDC-34226P, "PER Ch. E9: Prospective Radiological Assessment" (Reference 8-8)

Clear reference to the relevant chapters that provide further information on specific concepts, systems, and processes will be made throughout.

[1] The BWRX-300 design enables a refuelling outage duration of 12 days or less, except for one refuelling outage of 30 days or less every 10 years to accommodate less frequent inspections and maintenance activities (GEH SDD document 006N5377, "BWRX-300 Refueling and Servicing Equipment" (Reference 8-9)).

8.1 Regulatory Context

GEH has entered the GDA process up to Step 2 with the BWRX-300 design, before progressing directly to site licensing. This approach has been informed by regulatory guidance and decision documents, supplemented by regulatory engagement.

Several regulatory requirements and forms of guidance exist that relate to the sampling and monitoring of radioactive discharges as well as in-process monitoring. These have been outlined below, with the focus of each described.

The Environment Agency (EA) is working with the Office for Nuclear Regulation and Natural Resources Wales (NRW) in assessing the GDA submission. The EA's and NRW's regulatory responsibilities extend to England and Wales respectively. The EA and NRW are considered together as the environmental regulators.

8.1.1 Legislation

The main legislative requirements relevant to this chapter are from EPR16 (Reference 8-2).

A further requirement on sites with an Environmental Permitting Regulations (EPR) permit in England and Wales is that BAT is used for monitoring discharges. The concept of BAT is defined in the OSPAR Convention, "Convention for the protection of the marine environment of the north-east Atlantic" (Reference 8-10) and in 2008/1/EC, "Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control" (Reference 8-11). Further information on GEH's approach to assessing and demonstrating BAT is provided in NEDC-34223P, PER Ch. E6 (Reference 8-3).

2004/2/Euratom

The European Basic Safety Standards document, 2013/59/Euratom "Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom" (Reference 8-12), makes reference to 2004/2/Euratom, "Commission recommendation of 18 December 2003 on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation" (Reference 8-13) and the associated Corrigendum document, "Corrigendum to Commission Recommendation 2004/2/Euratom of 18 December 2003 on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation" (Reference 8-14).

The 2004/2/Euratom document (Reference 8-13) defines information selected for monitoring and reporting on radionuclides discharged or liable to be discharged from nuclear power reactors and reprocessing plants in normal operation. Within the recommendations, a number of key radionuclides and requirements for their detection limits are listed; these are reproduced in Table 8-1 and Table 8-2.

8.1.2 Requirements and Alignment with the RSR Objective, Principles, and Generic Developed Principles

The EA has set out their expectations on permit holders carrying out radioactive substances activities in their guidance "Radioactive Substances Regulation (RSR): objective and principles" (Reference 8-15) and "Radioactive substances management: generic developed principles" (Reference 8-16) documents. The requirements relating to sampling arrangements, techniques, and systems for measurement and assessment of discharges, and disposals of radioactive waste, are reproduced below, in accordance with the guidance "RSR generic developed principles: regulatory assessment" (Reference 8-16).

The relevant 'Radioactive Substances Management Developed Principles' (RSMDPs) are as follows:

RSMDP9 – characterisation

"Radioactive substances should be characterised using the best available techniques so as to facilitate their subsequent management, including waste disposal."

RSMDP13 – monitoring and assessment

"The best available techniques, consistent with relevant guidance and standards, should be used to monitor and assess radioactive substances, disposals of radioactive wastes and the environment into which they are disposed."

RSMDP14 – record keeping

"Sufficient records relating to radioactive substances and associated facilities should be made and managed so as: to facilitate the subsequent management of those substances and facilities; to demonstrate whether compliance with requirements and standards has been achieved; and to provide information and continuing assurance about the environmental impact and risks of the operations undertaken, including waste disposal."

The relevant 'Engineering Developed Principles' (ENDPs) are as follows:

ENDP4 – environment protection functions and measures

"Environment protection functions under normal and fault conditions should be identified, and it should be demonstrated that adequate environment protection measures are in place to deliver these functions."

A Forward Action has been raised in NEDC-34223P, PER Ch. E6 (Reference 8-3) with regards to development of the outline methodology for identifying and assigning Environment Protection Functions (EPFs) during GDA (FAP.PER6-306).

ENDP10 – quantification of discharges

"Facilities should be designed and equipped so that best available techniques are used to quantify the gaseous and liquid radioactive discharges produced by each major source on a site."

ENDP14 – control and instrumentation – environment protection systems

"Best available techniques should be used for the control and measurement of plant parameters and releases to the environment, and for assessing the effects of such releases in the environment."

Additional requirements relating to sampling and monitoring are provided in the regulators' GDA guidance document, "New nuclear power plants: Generic Design Assessment guidance for Requesting Parties" (Reference 8-17). This states that during the three step GDA process:

"The RP must provide details of their arrangements for:

- *In-process monitoring, including measuring parameters relevant to waste generation and management, and process control*
- *Monitoring final discharges of gaseous and aqueous wastes*
- *Monitoring disposals of non-aqueous liquid and solid wastes*

The RP must demonstrate that their proposals represent BAT for monitoring and confirm that the sensitivity is sufficient to:

- *Readily demonstrate compliance with the proposed limits*
- *Meet the levels of detection specified in 2004/2/Euratom, which we [the regulators] consider to be good practice*

The RP must describe the facilities provided for independent periodic sampling (by the regulator) of final discharges of gaseous and aqueous wastes."

The requirements specified in 2004/2/Euratom (Reference 8-13) are presented in Section 8.1.1.

8.1.3 Standards

The following standards are relevant to the development of the BWRX-300 sampling approach and will be considered throughout the GDA process and beyond.

The standards will be used to ensure BAT is being applied to the sampling and monitoring design of the BWRX-300.

BS ISO 2889:2023

ISO 2889:2023 is an International Organization for Standardization (ISO) international standard, which has been adopted as a British Standard (BS), BS ISO 2889:2023, "Sampling airborne radioactive materials from the stacks and ducts of nuclear facilities" (Reference 8-18). The standard contains sets of criteria and recommendations for sample extraction, sampling system design, sample transport, performance criteria, and quality control for gaseous discharges from nuclear facilities.

In addition, it contains Annexes which provide some options for collection and analysis of selected analytes.

ISO 10780:1994

ISO 10780:1994, "Stationary source emissions – Measurement of velocity and volume flowrate of gas streams in ducts" (Reference 8-19), is an international standard which specifies manual methods for determining the velocity and volume flow rate of gas streams in ducts, stacks, and chimneys vented to the atmosphere. The standard specifies the use of two types of Pitot tubes, type L and type S. This applies to gas streams with essentially constant density, temperature, flow rate, and pressure at the sampling point.

BS EN 60761-1:2004 and BS EN 60761-3:2004

The BS EN 60761:2004, "Equipment for continuous monitoring of radioactivity in gaseous effluents" series are international standards, which have been adopted as a BS based on IEC 60761:2002. BS EN 60761:2004 focuses on equipment for the continuous monitoring of activity in gaseous effluents. BS EN60761-1:2004, "Radiation protection instrumentation – Equipment for continuous monitoring of radioactivity in gaseous effluents. Part 1: General requirements" (Reference 8-20) focuses on the general requirements of continuous monitoring, of which there is some overlap with BS ISO 2889:2023 (Reference 8-18). The remainder of the series within this standard goes into detail for specific analytes, transuranics, noble gases, iodine, and tritium (see BS EN 60761-3:2004, "Equipment for continuous monitoring of radioactivity in gaseous effluents – Part 3: Specific requirements for radioactive noble gas monitors" (Reference 8-21)).

MCERTS and Guidance

The Monitoring Certification Scheme (MCERTS) is the EA's Monitoring Certification Scheme for environmental permit holders, detailed in the guidance "Minimum requirements for self-monitoring of flow: MCERTS performance standard" (Reference 8-22). Its purpose is to promote the production of quality monitoring data and provide the key foundation of the licensee's self-monitoring policy.

In addition to MCERTS there is also associated regulatory guidance.

MCERTS standards and guidance relevant to sampling and monitoring of the BWRX-300 (especially of discharges) include:

- EA: "Minimum requirements for self-monitoring of flow: MCERTS performance standard" (Reference 8-22)
- EA: "MCERTS performance standard for radioanalytical testing of environmental and waste waters" (Reference 8-23)
- British Standards Institution: BS EN ISO/IEC 17025:2017 "General requirements for the competence of testing and calibration laboratories" (Reference 8-24)
- EA: "Monitoring stack emissions: measurement locations" (Reference 8-25)
- EA: "Monitoring stack emissions: standards for continuous monitoring and sampling" (Reference 8-26)
- EA: "Monitoring stack emissions: techniques and standards for periodic monitoring" (Reference 8-27)

GEH note that there is guidance on environmental monitoring available from the environmental regulators ("Radiological monitoring technical guidance note 2, Environmental radiological monitoring" (Reference 8-28)) but this is out of scope at GDA Step 2. GEH recognise that environmental monitoring will have to be addressed for site-specific licensing/permitting. This is captured in the FAP (FAP.PER8-214).

8.2 Parameters to be Measured (Final Discharges)

8.2.1 Radionuclides

In 2004/2/Euratom (Reference 8-13), the key radionuclides are listed as in Table 8-1 and Table 8-2 (see Section 8.1.1). Based on the current End User Source Terms (EUST) for BWRX-300 radioactive discharges (see NEDC-34224P, PER Ch. E7 (Reference 8-7)), the radionuclides with the greatest activity (Bq/y) are:

- Noble gases, tritium, and carbon-14 for gaseous discharges; and
- Tritium for aqueous liquid discharges.[2]

Based on the assessments undertaken in NEDC-34226P, PER Ch. E9 (Reference 8-8) the radionuclides with the largest contribution of dose to the most exposed member of the public and non-human species (μSv/y or μGy/h) are:

- Carbon-14, iodine-131, and krypton-89 for gaseous discharges; and
- Cobalt-60, zinc-65, and phosphorus-32 for aqueous liquid discharges.

It should be noted that the BWRX-300 is capable of being operated, under normal operating conditions, without recourse to aqueous liquid discharges to the environment (see NEDC-34224P, PER Ch. E7 (Reference 8-7) and GEH's Design Basis Record (DBR) document DBR-0060900, "BWRX-300 Zero Release Plan" (Reference 8-30)). However, occasional aqueous liquid discharges may be required in order to maintain the overall water balance of the plant.

The 2004/2/Euratom significant radionuclides have not yet been fully established for both the gaseous and aqueous liquid discharges of the BWRX-300. NEDC-34224P, PER Ch. E7 (Reference 8-7) discusses the current limitations of the EUST for radioactive discharges.

The fact that the 2004/2/Euratom significant radionuclides have not yet been fully identified is recognised as a forward action (FAP.PER8-206) and is also raised in NEDC-34224P, PER Ch. E7 (Reference 8-7) (FAP.PER7-193). This item from PER Ch. E7 identifies that the current BWRX-300 EUST listed radionuclides for gaseous and aqueous liquid discharges do not exactly match those in the 2004/2/Euratom recommendation. Gaseous and aqueous liquid discharge data for BWRX-300 are presented in 007N1078, "Annual Average Gaseous Effluent Releases for the BWRX-300 Standard Plant" (Reference 8-31), and 007N1460, (Reference 8-29).

Based on the current EUST activities and the dose contribution, the proposed radionuclides for determination are shown in Table 8-3 and Table 8-4.

Information on the design of the BWRX-300 gaseous monitoring system (on the PVS) is provided in GEH's document 006N6319, "BWRX-300 D11 Process Radiation and Environmental Monitoring System Facility Diagram" (Reference 8-34).

The PING skid has an additional radiation detector to cover the extended range needed during accident conditions for noble gases (006N6319 (Reference 8-34)).

The information on sampling of aqueous liquids prior to discharge is provided in the relevant GEH SDD documents, 006N7729, "BWRX-300 Liquid Waste Management System" (LWM) (Reference 8-35) and 006N7938, "BWRX-300 Process Radiation and Environmental Monitoring System" (PREMS) (Reference 8-36).

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[2] Tritium is excluded from GEH's analysis on aqueous liquid discharges activities presented in 007N1460, "BWRX-300 Annual Average Liquid Effluent Activity Releases" (Reference 8-29). The bounding case for discharge of tritium via the aqueous pathway for the BWRX-300 is resented in NEDC-34224P, PER Ch. E7 (Reference 8-8), based on the assumptions stated therein.

The aqueous liquid discharge pipe is fitted with a radiation detector (part of the Process Radiation Monitoring Subsystem (PRM)) that monitors any discharge to the Circulating Water System (CWS). If activity above a preset limit is detected, the discharge pipe will be automatically isolated by two air operated valves (006N7729, LWM SDD (Reference 8-35)).

8.2.2 Discharge Flows

To be able to report accurately the discharge of radioactive material from release points, the volumetric flow of both gaseous and liquid effluent streams needs to be continuously measured using an appropriate MCERTS accredited technique (see MCERTS performance standard (Reference 8-22)).

The type and location of a flow meter(s) for gaseous discharge not yet been incorporated into the BWRX-300 design. This lack of a flow meter is recognised as a forward action (FAP.PER8-310).

The BWRX-300 design has a flow element included in the aqueous liquid discharge pipe from the sample tanks to the CWS (and thereby to the marine environment) (006N6319, PREMS SDD (Reference 8-34) and 006N7729, LWM SDD (Reference 8-35)).

The actual flow meter type(s) has not been selected at this stage (GDA Step 2) as to do so would foreclose options later in the design process. This is for the future owner/operator to determine. It is recognised that any selected flow equipment will be required to meet MCERTS standards and be demonstrated to be BAT.

The requirement to select sampling and monitoring equipment at a later stage is recognised as a forward action (FAP.PER8-209).

8.3 Safety Categorisation and Classification

The sampling system, as well as the continuous monitoring system, provides essential information for determining radiological risk and supports plant operations to demonstrate that risk is reduced to a level deemed As Low As Reasonably Practicable (ALARP). ALARP is a UK legal requirement that limits exposure to radiation and is a key part of UK radiation protection. This principle requires employers to take steps to reduce the amount of radiation their employees and members of the public are exposed to and ensures that workers work down from dose limits rather than up to them.

The BWRX-300 safety categorisation and classification for the sampling and monitoring systems is presented in document 006N7938, GEH's PREMS SDD (Reference 8-36).

The safety class ratings are based on the function of the sampling/monitoring system and their location.

The categorisation and classification of equipment will continue as the Pre-Construction Safety Report (PCSR) develops and may impact upon the sampling and monitoring regime deployed in the BWRX-300. These refinements will be included in later steps in the permitting and licensing process (FAP.PER8-209).

8.4 System and Equipment Design

8.4.1 GDA Submission Scope

It is not deemed appropriate to provide details of the precise sampling and monitoring equipment at the GDA stage, as technological development progresses at pace and GEH would not be applying BAT at the time of procurement if the equipment to be used is stated at this stage.

The design of sampling and monitoring arrangements for BWRX-300 is evolving and subject to change. However, current descriptions of the relevant systems are presented in NEDC-34221P, PER Ch. E4 (Reference 8-5).

As stated previously in Section 8.2.2, the requirement to select sampling and monitoring equipment at a later stage is recognised as a forward action (FAP.PER8-209).

Although the approximate locations of the sampling and monitoring equipment are identified in the BWRX-300 design, the precise positioning will be undertaken at a later design development stage (FAP.PER8-311).

8.4.2 Sampling and Monitoring Locations for Radioactive Discharges

The final discharge points in the BWRX-300 design have been identified to ensure an accurate record of discharge to the environment can be made. Two locations within the design have currently been identified:

- The final discharge point for gaseous discharge is the PVS; and
- The final discharge point for aqueous liquid discharges is the CWS.

Both final sampling locations are downstream of any treatment systems and hence provide an accurate record of the composition of discharges to the environment.

In addition to the discharge points there are locations within the plant where in-process monitoring and sampling occur. The selection of the locations of these is expanded upon within Section 8.4.6.

Gaseous Discharge Routes

The gaseous discharge routes for the BWRX-300 plant are described in detail in 006N7781, GEH's HVS SDD (Reference 8-1) and 006N7899, "BWRX-300 Offgas System" (Reference 8-37), and are summarised in NEDC-34224P, PER Ch. E7 (Reference 8-7).

The point for gaseous discharge is through the PVS, located on the top of the Turbine Building (TB). The top of the PVS is at 35 m above the ground elevation (005N9751, "BWRX-300 General Description" (Reference 8-38)). The main stack accepts gaseous effluent from the HVS lines, the turbine gland seal subsystem line, the mechanical vacuum pump line, and the Offgas System (OGS) line.

Aqueous Liquid Discharge Routes

The LWM for the BWRX-300 plant is described in detail in 006N7729, LWM SDD (Reference 8-35), and is summarised in NEDC-34224P, PER Ch. E7 (Reference 8-7).

Should an aqueous liquid discharge be required, the Waste Sampling Subsystem is equipped with a discharge path to the CWS for release to the environment. The discharge path is equipped with a radiation monitor and a sample line.

8.4.3 Gaseous Discharge Sampling

The final gaseous discharge point, the PVS, is discussed in Section 8.4.2. A sampling probe (final design is to be determined) is positioned within the PVS. From the sampling probe the sample is sent to a PING skid (006N7938, PREMS SDD (Reference 8-36)). Figure 8-1 (extracted from 006N6319, PREMS facility diagram (Reference 8-34)) shows the arrangement.

The PING skid is part of the PRM and is an offline radiation monitor. The PING skid is a three-channel non-redundant radioactivity monitoring assembly that continuously monitors for particulates, iodine, and noble gases (006N6319, PREMS facility diagram (Reference 8-34)). After sampling, the remnants of the flow are returned to the PVS.

Further information on the PRM is provided in Section 8.4.6.

There are currently no details of the sampling probe design as this will be the responsibility of the future owner/operator (FAP.PER8-209). It is recognised that the sampling probe will have to meet the requirements discussed in Section 8.1.3. This means that:

- The probe should be an isokinetic probe;
- Heating should be applied to the sampling line;
- Calculations will be required to ensure that adequate mixing has been completed before sampling;
- Safe access to the sampling port(s) will be required; and
- Independent sampling provision will neeed to be included.

The BWRX-300 sampling and monitoring regime for tritium and carbon-14 in gaseous discharges is yet to be determined. It is anticipated that techniques for monitoring tritium and carbon-14 by sampling, laboratory analysis, and calculation will be utilised, that are already known and employed across the nuclear industry (see STI/DOC/010/421 (Reference 8-32) and EPRI 1021106 (Reference 8-33)).

8.4.4 Aqueous Liquid Discharge Sampling

The final aqueous liquid discharge point, the CWS, is discussed in Section 8.4.2.

The discharge path contains a locked closed manual valve, a radiation monitor, sample line, flow control valve, flow element, and two air operated valves for automatic isolation if radiation greater than a preset limit is detected in the flow stream. A demineralised water line from the Water, Gas, and Chemical Pads (WGC) system is provided for flushing the discharge line (006N7729, LWM SDD (Reference 8-35)).

The PREMS provides radiation monitoring of the LWM. One triple modular redundant set of radiation monitors is installed on the LWM discharge to the CWS. The Distributed Control and Information System (DCIS) for the LWM includes logic to automatically secure discharge to the CWS upon detection of radiation above preset limits (006N7938, PREMS SDD (Reference 8-36)).

The radiation monitor is upstream of the discharge into the CWS and is positioned adjacent to the line (006N7938 (Reference 8-36)).

Prior to any discharge the liquid in the sample tank is thoroughly mixed and sampled. Details of the sampling subsystem are provided in 006N7729, LWM SDD (Reference 8-35) and NEDC-34224P, PER Ch. E7 (Reference 8-7).

Automated sample panels are fitted onto the respective pipelines associated with the two sample tanks (006N7938, PREMS SDD (Reference 8-36)).

The configuration of the waste sampling subsystem of the LWM is shown in Figure 8-2.

8.4.5 Solid Waste and Non-Aqueous Liquid Sampling

The solid radioactive wastes generated by the BWRX-300 are similar to those generated from the UK ABWR. This is discussed in NEDC-34222P, PER Ch. E5 (Reference 8-6), which describes the Radioactive Waste Management Arrangements (RWMA) for the BWRX-300.

The chapter identifies those parts of the RWMA that are part of the current BWRX-300 design and those that are indicative and will need to be developed at a later stage.

Wet solid radioactive wastes such as spent bead resins, filter backwash sludges and granular activated carbon are routed to the Solid Waste Management System (SWM) for onward management (see NEDC-34222P, PER Ch. E5 (Reference 8-6) and GEH's SDD document 006N7733, "BWRX-300 Solid Waste Management System" (Reference 8-39)). The spent bead resins and sludges are temporarily stored in the spent resin or sludge storage tanks respectively, before onward management (006N7733, SWM (Reference 8-39)). The spent resin and sludge storage tanks can be recirculated to allow mixing of the tank contents and collection of representative samples (006N7733 (Reference 8-39)). The SWM provides process water to the PREMS for chemistry monitoring. Samples are taken from the following locations and routed to a local grab sample station (006N7938, PREMS SDD (Reference 8-36)):

- Each sludge storage tank
- The spent resin storage tank
- The tank dewatering line

The BWRX-300 is a first-of-a-kind reactor. As the SWM is still in development with much of the future design being dependent on characterisation of wastes that have not yet been produced, specific details of the required sampling, monitoring, and characterisation regime cannot be determined.

Any future sampling, monitoring, and characterisation will be based on Good Practice Guidance such as that outlined in the following reports and guidance documents:

- Nuclear Decommissioning Authority: "Solid Radioactive Waste Characterisation Good Practice Guide" (Reference 8-40)
- International Atomic Energy Agency: IAEA-TECDOC-1537, "Strategy and Methodology for Radioactive Waste Characterization" (Reference 8-41)
- Nuclear Waste Services: DEPWMP48-TR05, "Characterisation Good Practice Model" (Reference 8-42)

GEH recognises that the requirements for characterisation of the solid radioactive wastes arising from BWRX-300 cannot be fully established at GDA Step 2 (FAP.PER8-211).

8.4.6 Process Sampling and Monitoring

There are two process sampling and monitoring systems employed in the BWRX-300 design. These are the PREMS and the water chemistry sampling and monitoring system. Full details of both systems are provided in 006N7938, PREMS SDD (Reference 8-36) and the DBR document DBR0060012, "BWRX-300 Water Chemistry Sampling and Monitoring" (Reference 8-43).

PREMS

Document 006N7938 (Reference 8-36) defines the complete set of requirements for the PREMS. The document identifies the requirements for the associated Structures, Systems, and Components (SSCs), provides the basis for inclusion of requirements, and describes the features of the system design provided to meet those requirements. The document is intended to be used in support of design development, design verification, turnover, startup testing, and commissioning activities. An overview of the PREMS design is also presented in NEDC-34221P, PER Ch. E4 (Reference 8-5).

The PREMS acts as a detection system to identify when plant conditions change from normal, providing operators with an 'early warning' and the necessary information to maintain the health and reliability of the plant systems.

The PREMS is made up of the following subsystems (006N7938, PREMS SDD (Reference 8-36)):

- PRM. The PRM monitors various process and effluent streams for radioactivity arising from noble gases, air particulates, and halogens. The PRM may also include toxic gas monitoring if required by location or utility (determined during site-specific design phase).
- Area Radiation Monitoring Subsystem (ARM). The ARM monitors gamma radiation levels in strategic locations throughout the plant (excluding containment).
- Containment Monitoring Subsystem (CMon). The CMon monitors containment pressure, temperature, water level, hydrogen concentration, oxygen concentration, Fission Products (FP), and area radiation levels in containment.
- PS. The PS collects representative process samples for analysis and provides the analytical information required for monitoring plant and equipment performance.

Process Radiation Monitoring Subsystem

The PRM monitors various process and effluent streams for potentially hazardous contamination by measuring the radioactivity of noble gases, air particulates, and halogens. The PRM does not support any Defence Line (DL) functions but supports the Fundamental Safety Function (FSF) of confinement of radioactivity (006N7938, PREMS SDD (Reference 8-36)). The PRM provides an assortment of monitoring equipment, with each device being tailored to the process/effluent stream according to fluid, location, and radiological hazard. In general, the following types of monitoring equipment are used (006N7938 (Reference 8-36)):

- Offline radiation monitors: Radiation monitoring assemblies that are installed external to and away from the process stream. A continuous sample is extracted from the process and/or effluent stream and conveyed to the assembly. For example, combination skids that measure particulate, iodine, and noble gas activities are commonly known as PING skids. PING skids typically include three independent analysers (three channels), flow extraction/control equipment, grab sampling taps, a local control panel, and audible/visual alarms. Particulate filters, iodine filters (charcoal cartridges), and grab samples are periodically collected from the skids for isotopic analysis.
- Inline radiation monitors: Single radiation detection element installed in the process stream. This could be a scintillation detector or an ionisation chamber and is used to measure beta or gamma radiation.
- Adjacent-to-line madiation monitors: Single radiation detection element mounted externally to the process line. This could be a scintillation detector or an ionisation chamber and is used to measure beta or gamma radiation.
- Area radiation monitors: General area radiation monitor. This could be a scintillation detector or an ionisation chamber and is used to measure gamma radiation.

Real-time measurements are displayed in the Control Room (CR) with alarms to notify personnel when measurements exceed preset limits. Local indication and alarms are provided where necessary to notify personnel of hazardous conditions.

Systems employing automatic functions are provided with sufficient instrumentation to communicate with the DCIS. It should be noted that the PRM provides instrumentation and signal only, and all control logic is provided by the DCIS and/or responding system. The following automatic functions are supported by the PRM:

- LWM discharge: LWM discharge to the CWS is halted, with isolation of the discharge line, if radiation above preset limits is detected at the offsite discharge line.

- OGS discharge: OGS discharge to the HVS is secured if high radiation is detected downstream of the charcoal adsorber beds.
- Lower Reactor Building (RB) HVS intake: HVS Secondary Control Room (SCR) emergency filter units and pressurisation fans are aligned to provide safe breathing air to the SCR if high radiation (or toxic gas, if applicable) is detected at either of the lower RB supply Air Handling Units (AHUs).
- RB HVS exhaust: RB HVS exhaust is secured if high radiation is detected at the lower RB HVS exhaust or refuel floor/fuel pool area HVS exhaust.
- CB HVS intake: HVS Control Room Emergency Envelope Filter Units (CREEFUs) (and/or toxic gas filter units, if applicable) are aligned to provide safe breathing air to the CR if high radiation (and/or toxic gas, if applicable) is detected at either of the CB supply AHUs.

A summary of the PRM monitoring for gaseous flows is shown in Table 8-5 (extracted from 006N7938, PREMS SDD (Reference 8-36)), and Figure 8-3 gives a simplified overview of the PRM.

The final design of the monitoring configuration is to be made during the site-specific design stage (FAP.PER8-209).

Area Radiation Monitoring Subsystem

The ARM monitors gamma radiation levels in strategic locations throughout the plant (excluding containment). The ARM supports DL2 functions by monitoring area radiation levels on the refuelling floor. The ARM also supports the FSF of confinement of radioactivity (006N7938, PREMS SDD (Reference 8-36)).

Real-time measurements are displayed in the CR with alarms to notify personnel when radiation levels exceed preset limits. Local indication and alarms are provided where necessary to notify personnel of hazardous conditions.

Detectors can be of the scintillation or ionisation chamber design and are used to measure gamma radiation (006N7938 (Reference 8-36)).

Containment Monitoring Subsystem

The CMon monitors the following containment variables:

- Containment pressure
- Containment temperature
- Containment water level
- Containment hydrogen concentration
- Containment oxygen concentration
- Containment Fission Product (FP)
- Containment area radiation levels

The CMon supports DL3 and DL4a functions by monitoring containment pressure. The CMon also supports the FSF of confinement of radioactivity (006N7938, PREMS SDD (Reference 8-36)).

Real-time measurements are displayed in the CR with alarms to notify personnel when measurements exceed preset limits. Local indication and alarms are provided where necessary to notify personnel of hazardous conditions.

Systems employing automatic functions are provided with sufficient instrumentation to communicate with the DCIS. It should be noted that the CMon provides instrumentation and signal only, and all control logic is provided by the DCIS and/or responding system.

CMon instrumentation is described in further detail in 006N7938 (Reference 8-36). A summary of the CMon instrumentation is provided in Table 8-6, and Figure 8-4 shows the instrument locations inside and outside of containment (006N7938 (Reference 8-36)).

Process Sampling Subsystem

The PS collects representative process samples for analysis and provides the analytical information required for monitoring plant and equipment performance. The PS does not support any DL functions. PS equipment containing radioactive material supports the FSF of confinement of radioactivity (006N7938, PREMS SDD (Reference 8-36)).

For processes requiring continuous (or frequent) monitoring, sample tubing is routed from the process stream to one of three automated sample panels. Sample conditioning equipment is provided within each panel for pressure, temperature, and flow adjustment. Online monitoring equipment is used to the greatest extent practicable, and provided for measurements such as conductivity, dissolved oxygen, dissolved hydrogen, Total Organic Carbon (TOC), and silica. Grab sample taps are provided at the panels for infrequent/diagnostic sampling, online analyser checks, and instances in which online analysers are unavailable. Test connections are provided for equipment calibration or installation of temporary analysers.

Instrument data is displayed locally at the panel, with alarms to notify personnel when measurements exceed preset limits. Instrument data is provided to the DCIS and made available for use with third-party laboratory trending/reporting software. Only parameters critical to plant operation are displayed in the CR, with alarms to notify personnel when measurements exceed preset limits.

Most processes requiring infrequent (or diagnostic only) sampling are collected via local grab sample stations. If necessary, sample conditioning equipment is provided with each station for pressure, temperature, and flow adjustment (006N7938 (Reference 8-36)).

Table 8-7 lists processes monitored via automated sample panels, and Table 8-8 lists processes monitored via local grab sample stations (006N7938 (Reference 8-36)).

The design basis of the PS panels is described in detail in GEH's DBR document DBR-0070157, "Design Basis of Process Sample Panels" (Reference 8-44).

Water Chemistry Sampling and Monitoring

The BWRX-300 uses high purity water as the fluid to transfer thermal energy. The quality of water to which the component is exposed largely determines the reliability and lifetime of that component. The extent of materials corrosion from its environment is a function of impurity and its concentration, temperature, and time. Reliable maintenance of water quality is necessary to achieve the desired overall plant reliability and availability (DBR-0060012, "BWRX-300 Water Chemistry Sampling and Monitoring" (Reference 8-43)).

GEH's Water Chemistry Sampling and Monitoring DBR document (DBR-0060012 (Reference 8-43)) provides a description of the BWRX-300 water chemistry sampling and monitoring programme. This water sampling and monitoring programme is designed to analyse and monitor system chemistry for trending with alarm notification so actions can be taken to stay within operating specifications. This supports minimising corrosion from chemical contaminants and monitoring chemical additives used to limit corrosion and radiation buildup. This document lists the recommended in line sampling parameters by system and possible location as well as typical grab sample analyses. EPRI action levels and basis for the specific chemistry parameters are listed to support the required and recommended sampling system measurements. This also includes some systems or sampling not included in the PREMS, notably sampling of various tanks.

The DBR document provides a Table (DBR-0060012 (Reference 8-43)) that details the PS measurements. This is reproduced in Table 8-9.

8.4.7 Chemistry Laboratory

The BWRX-300 design includes an on-site chemistry laboratory. The laboratory is located in the Radwaste Building (RWB) on the 6.1 m level, as shown in 008N0988, “BWRX-300 Power Block PSAR General Arrangement” (Reference 8-45). The chemistry laboratory also contains a counting room for radiochemical analysis.

The chemistry laboratory is used to prepare and analyse all grab samples in the plant as well as some outside systems and tanks. Samples that are analysed in the chemistry laboratory may contain radioactivity. The chemistry laboratory also provides a backup analytical capability for inline instrumentation. A data processing area is included in the chemistry laboratory, as well as areas for instruments, sample preparation, and storage (see GEH’s design specification document 007N3673, “Chemistry Laboratory Requirements” (Reference 8-46)).

The counting room provides activity measurements for isotopic analyses for all radiological effluent releases. This does not typically include the radiological environmental monitoring program due to background activity. The counting room can be separated from the chemistry laboratory for control of environment (temperature and background radiation levels). If included in the chemistry laboratory, it is typically confined by doors, walls, and shielding, as appropriate (007N3673 (Reference 8-46)).

The design specification of the laboratory is provided in 007N3673 (Reference 8-46).

It is recognised by GEH that the design specification for the laboratory is tailored to meeting U.S. requirements and therefore the future owner/operator in the UK will have to ensure that UK requirements are met. It is expected that this will include ensuring the laboratory meets BS EN ISO/IEC 17025:2014 (Reference 8-24) and that the methods used for analysing radioactive discharges are MCERTS accredited.

Some of the potential wet solid radioactive wastes generated from the operation of the BWRX-300 may arise as Intermediate Level Waste (ILW) (see NEDC-34222P, PER Ch. E5 (Reference 8-6) that will require characterisation. The future owner/operator will need to determine if the on-site laboratory will undertake analysis of these samples or if an off-site laboratory will be used (FAP.PER8-213).

8.5 Demonstration of BAT (Claims and Arguments)

The GEH BWRX-300 is designed to minimise the radiological impact to the environment and the public. As the design progresses through the GDA process and onto licensing and permitting, the minimisation of the radiological impact will be demonstrated to be BAT. At Step 2 of the GDA assessment, only the claims and arguments of the BAT process are presented.

GEH recognises that there is a requirement to collate evidence to underpin claims and arguments, when needed in the future (FAP.PER8-212).

The methodology of how BAT will be demonstrated for the BWRX-300 is described in NEDC-34223P, PER Ch. E6 (Reference 8-3). The sampling and monitoring of radioactive substances provides information to support the demonstration of BAT.

The environmental claims structure for the PER is presented in GEH's document NEDC-34141P, "Environmental Strategy" (Reference 8-47). The environmental Level 2 claims relevant to this chapter are:

- 1.2. Minimisation of the activity of gaseous radioactive waste disposed of by discharge to the environment
- 1.3. Minimisation of the activity of aqueous radioactive waste disposed of by discharge to the environment
- 1.6. Minimisation of the impact of radioactive discharges on members of the public and the environment

In the GEH BWRX-300, the sampling arrangements and radiation monitoring system are designed to fulfil the following three specific claims:

- Claim 1: Verify that radioactive discharge to the environment complies with the Permit[3]
- Claim 2: The data provided to assess the radiological impacts to the public and the environment is robust
- Claim 3: Minimise radioactive discharge to the environment

Arguments to support the three claims are provided in the following sections. Supporting evidence is not provided at this stage of the GDA (Step 2).

8.5.1 Claim 1: Verify that Radioactive Discharge to the Environment Complies with the Permit

The BWRX-300 will comply with the requirements of the environmental permit and will provide appropriate means to judge compliance.

This claim is based on the following arguments.

Argument 1a: All Final Radioactive Discharge Points or Paths to the Environment Throughout the BWRX-300 are Identified

To be able to comply with the permit, it is necessary to be able to:

- Identify all locations where a radioactive gaseous or aqueous liquid discharge occurs
- Know on a realistic basis the volumes and activities of each radioactive discharge
- Identify the significant radionuclides of each radioactive discharge
- Know on a realistic basis the frequency of each radioactive discharge.

[3] The "Permit" is the future permit which is currently envisaged for use by the future licensee under the RSR regime.

Only when the location, activity, volume, and significant radionuclides for a radioactive discharge are identified can suitable sampling, and monitoring arrangements, and equipment, be determined.

Argument 1b: Activity and Volume of Discharges to the Environment are Evaluated Based on Actual Measured Data

The total activity discharged to the environment will be confirmed and compared against the permitted limit. Radioactive gaseous and aqueous liquid discharges will be monitored to evaluate the total activity discharged to the environment. For this evaluation, the following parameters will be measured:

- Activity concentration of the discharge
- Discharge flow rate
- Discharge time

From the discharge flow rate and discharge time, the flow is integrated to obtain total volume of the discharge. Then the activity concentration is multiplied to derive the total activity discharged. The discharge flow rates will be measured by specific instruments.

The activity concentration is evaluated from the sample measurement which consists of the following parameters:

- Activity of the sample
- Sampling flow rate
- Sampling period

The sampling and monitoring system is designed to be operable whenever gaseous and aqueous liquid wastes are being discharged to the environment. This includes both continuous and batch discharges.

Argument 1c: Measurements are Recorded

To enable demonstration that the permit conditions are being complied with, all relevant measurements as identified in the permit will be automatically recorded. To ensure that recordings are undertaken, suitable sampling and monitoring equipment will be used.

Where measurements cannot be automatically recorded then appropriate management arrangements will be in place to ensure measurements are manually undertaken.

8.5.2 Claim 2: The Data Provided to Assess the Radiological Impacts to the Public and the Environment is Robust

The BWRX-300 design includes a range of features that contribute to the substantiation of this claim, including:

- Provision for collecting data on the levels of activity discharged to the environment, which is essential for the assessment of radiological impacts
- Provision for measurements to be undertaken using appropriate methodologies such that the data collected is precise and accurate, and therefore suitable for undertaking impact assessments

This claim is based on the following arguments.

Argument 2a: Representative Gaseous Samples are Collected and Measured Prior to Discharge

The gaseous discharge is measured at the PVS, which is located on the TB roof. The PVS design is known, such that the requirements to undertake representative sampling can be determined. Additionally, the flow characteristics of the radioactive discharge are understood, such that the requirements to undertake representative sampling can be determined.

The following features of the PVS sampling and monitoring system support collection and analysis of representative gaseous samples:

- The sampling point within the stack is selected to ensure that the gases are well mixed prior to sampling. This ensures that the collected sample is representative of the gaseous discharge.
- The gaseous flow will be continuously measured. This will allow accurate gaseous discharge flow volumes to be recorded, allowing total activity discharged to be monitored.
- Commissioning of the gaseous sampling system will determine the air velocity profile to show the coefficient of variance is less than 20 % across the centre two thirds of the stack.
- Redundancy is built into the PVS sampling and monitoring system. This ensures that if there is a failure then potential downtime is minimised.

Samples will be collected using a probe(s) that meet regulatory requirements, standards, and guidance (e.g., ISO BS 2889:2023 (Reference 8-18)). The samples are extracted (via a pipe) to the sampling station. Pipe bends and length are minimised, and where necessary heated to minimise deposition within the sampling line. The sampling platform will comply with regulator guidance (see the EA's guidance "Monitoring stack emissions: measurement locations" (Reference 8-25)), allowing workers safe access for periodic inspection and maintenance.

The selected location of the sampling equipment room is considered to meet with the following requirements:

- Assists in the sample being representative (minimum sampling pipe length and bends)
- Enables periodic worker accessibility to the room to collect the samples
- Contains enough maintenance space for the equipment
- Radiation protection
- Post-accident accessibility

Argument 2b: Representative Aqueous Liquid Samples are Collected and Measured Prior to Discharge

The processed aqueous liquid effluent is held in sample tanks prior to recycling to the Condensate Storage Tank (CST) or discharge to the environment via the CWS return line. The sample tanks are fitted with eductors to efficiently provide a homogenous mixture of the tank contents prior to sampling (006N7729, LWM SDD (Reference 8-35)). This provides a system to ensure that the contents are thoroughly mixed and representative. The pipeline is fitted with a sampling system allowing samples to be collected and analysed prior to any discharge. This allows the activity of the Sample Tank contents to be known before discharge.

The batch volume is known before discharge based on the sample tank volume. The discharge line to the CWS is also fitted with a flow meter. This allows the volume discharged to be known.

Argument 2c: Gaseous Activity Measurements will be Undertaken Using Appropriate Techniques and Measurements

The continuous monitoring of noble gases at the BWRX-300 PVS is performed by a gamma detector. The gas chamber size and geometry are optimised for the detector to ensure that the required limits of detection can be met. The PVS will also be fitted with an MCERTS accredited flow meter.

Collected samples are analysed in a certified laboratory (BS EN ISO/IEC 17025:2017 accredited (Reference 8-24)) and using analytical methods that are MCERTS where it applies. The laboratory can meet the required limits of detection for the significant radionuclides.

Sample collection periods are linked to the reporting period and with built-in redundancy. Samples are also collected in an appropriate order to minimise plating out and ensure that the most representative sample is collected.

Where measurements are required for monitoring BWRX-300 performance, rather than discharge, then the sampling and monitoring locations are selected at the most appropriate position. This is not necessarily at the PVS.

Argument 2d: Aqueous Liquid Activity Measurements will be Undertaken Using Appropriate Techniques and Measurements

The aqueous discharge pipeline is fitted with a MCERTS approved flow meter.

Collected samples are analysed in a certified laboratory (BS EN ISO/IEC 17025:2017 (Reference 8-24) accredited) and using analytical methods that are MCERTS where it applies. The laboratory can meet the required limits of detection for the significant radionuclides.

8.5.3 Claim 3: Minimise Radioactive Discharge to the Environment

The BWRX-300 monitors plant performance as well as radioactive discharge. When deviation from the normal value is detected, measures will be taken to minimise radioactive discharges to the environment.

This claim is based on the following arguments.

Argument 3a: Monitoring and Sampling Arrangements are Provided to Detect Deviation from the Normal Operations State

Changes to the noble gas activity provide indication of deviations from the normal operating state. The major source of any increase in the noble gas activity is fuel failure. Continuous monitoring of the noble gases at the PVS allows trends and deviations from normal operations to be detected and recorded. In-plant monitoring of the most appropriate systems allows early detection (before the PVS) of deviations of noble gas activity. This is supplemented by grab sampling systems that allow confirmatory and more detailed analysis to be undertaken.

Key features of the BWRX-300 design to support detection of deviation from the normal operations state include:

- Monitoring and sampling equipment is appropriately located or shielded to ensure that measurements are undertaken in a low background radiation area.
- The most appropriate radionuclides are selected for monitoring and sampling for maximum sensitivity when detecting deviation from the normal operating state.
- Radiation detectors are provided within selected parts of the HVS and OGS systems to allow identification of the source of any deviation in activity in the PVS.

The aqueous liquid collection and sample tanks are fitted with sampling systems. This allows any deviation from normal activity to be identified either before treatment with the LWM filtration skids or recycling to the CST or, if necessary, discharge to the environment.

Argument 3b: For Aqueous Liquid Batch Discharge, Means are Provided to Prevent Human Error

Administrative controls are in place to enable the operator to make a discharge from the aqueous liquid sample tank. This ensures that the correct sequence of events is undertaken to ensure the discharge is correct, as summarised below:

- All tank inlet valves close on the discharging sample tank when the Discharge Mode is selected by the operator, such that the tank does not receive any additional content (006N7729, LWM SDD (Reference 8-35)). This prevents unsampled and uncharacterised aqueous liquid being added to the discharge.
- The sample tank discharge line is fitted with a radiation monitor to detect elevated activity. This is fitted with an automatic closure system. This ensures that radioactivity of aqueous liquids being discharged remains below permitted limits.

8.6 Independent Sampling

It is recognised that to meet UK requirements, independent sampling systems will need to be provided for the final discharge points for use by the regulator or their representatives.

Currently the BWRX-300 standard design does not incorporate an allowance for independent sampling systems. This current omission is understood and acknowledged (FAP.PER8-207 and FAP.PER8-208).

Although no options will be foreclosed at this stage of the design process, it is envisaged that any independent sampling and monitoring systems will mirror (as far as is reasonably practicable) those used by the operator.

The use of any independent sampling system provided for use by the regulators should be designed such that it will not interrupt the operator's own sampling or off-set the quality of that measurement. The design should also ensure that there is sufficient space to accommodate the requirements for independent sampling.

Table 8-1: Key Radionuclides and Requirements for the Detection Limit in 2004/2/Euratom (Nuclear Power Reactors Gaseous Discharges)

Category	Key Radionuclides	Requirement for the detection limit (Bq/m^3)
Noble Gases Ar-41, Kr-85, Kr-85m, Kr-87, Kr-88, Kr-89, Xe-131m, Xe-133, Xe-133m, Xe-135, Xe-135m, Xe-137, and Xe-138	Kr-85[1]	1E+04[2]
Particulates (excluding iodines) Cr-51, Mn-54, Co-58, Fe-59, Co-60, Zn-65, Sr-89, Sr-90, Zr-95, Nb-95, Ag-110m, Sb-122, Sb-124, Sb-125, Cs-134, Cs-137, Ba-140, La-140, Ce-141, Ce-144, Pu-238, Pu-239 + Pu-240, Am-241, Cm-242, Cm-243, and Cm-244 Total-alpha[3]	Co-60 Sr-90 Cs-137 Pu-239 + Pu-240[3] Am-241[3] Total alpha[3]	1E-02 2E-02 3E-02 5E-03 5E-03 1E-02
Iodines I-131, I-132, I-133, and I-135	I-131	2E-02
Tritium	H-3	1E+03
Carbon-14	C-14	1E+01

Notes:

1. For Light Water Reactor.
2. Can normally be obtained by beta-measurement after decay of short-lived isotopes.
3. Total-alpha should only be reported if radionuclide-specific information on alpha-emitters is not available.

Note any radionuclides that are only relevant to gas cooled reactors have been omitted.

Table 8-2: Key Radionuclides and Requirements for the Detection Limit in 2004/2/Euratom (Aqueous Liquid Discharges)

Category	Key Radionuclides	Requirement for the detection limit (Bq/m^3)
Tritium	H-3	1E+05
Other radionuclides Cr-51, Mn-54, Fe-55, Fe-59, Co-58, Co-60, Ni-63, Zn-65, Sr-89, Sr-90, Zr-95, Nb-95, Ru-103, Ru-106, Ag-110m, Sb-122, Te-123m, Sb-124, Sb-125, I-131, Cs-134, Cs-137, Ba-140, La-140, Ce-141, Ce-144, Pu-238, Pu-239 + Pu-240, Am-241, Cm-242, Cm-243, and Cm-244 Total-alpha[1]	Co-60	1E+04
	Sr-90	1E+03
	Cs-137	1E+04
	Pu-239 + Pu-240[1]	6E+03
	Am-241[1]	5E+01
	Total alpha[1]	1E+03

Note:

1. Total alpha should only be reported if radionuclide specific information on alpha emitters is not available.

Note any radionuclides that are only relevant to gas cooled reactors have been omitted.

Table 8-3: Radionuclides to be Measured in BWRX-300 Gaseous Discharges

Category	BWRX-300 Designed Sampling and Monitoring Regime	2004/2/Euratom Key Radionuclides	Significant Radionuclides (Based on EUST and dose contribution)
Noble gases	Particulates, Iodine, and Noble Gases (PING) skid: The PING skid is a three-channel non-redundant radioactivity monitoring assembly that continuously monitors for particulates, iodine, and noble gases.	Kr-85	Kr-89 Other noble gases
Particulates (excluding iodines)		Co-60 Sr-90 Cs-137 Pu 239 + 240 Am-241 Total alpha[1]	Not applicable
Iodines		I-131	I-131
Tritium	See note[2]	H-3	H-3
C-14		C-14	C-14

Notes:

1 Total alpha should only be reported if radionuclide-specific information on alpha-emitters is not available.

2 The BWRX-300 sampling and monitoring regime for tritium and carbon-14 in gaseous discharges is yet to be determined. However, several techniques for monitoring of tritium and carbon-14 by sampling and laboratory analysis are known and employed across the nuclear industry (see International Atomic Energy Agency technical report STI/DOC/010/421, "Management of Waste Containing Tritium and Carbon-14" (Reference 8-32)). Methodology developed by EPRI for calculation of carbon-14 generation and release through gaseous effluent pathways may also be utilised, as presented in EPRI 1021106, "Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents" (Reference 8-33).

Table 8-4: Radionuclides to be Measured in BWRX-300 Aqueous Liquid Discharges

Category	BWRX-300 Designed Sampling and Monitoring Regime	2004/2/Euratom Key Radionuclides	Significant Radionuclides (Based on EUST and dose contribution)
Tritium	Sampling of sample tanks and laboratory analysis prior to discharge. This is part of the Process Sampling Subsystem (PS) (sample panel).	H-3	H-3
Other radionuclides		Co-60 Sr-90 Cs-137 Pu 239 + 240 Am-241 Total alpha[1]	Co-60 Zn-65 P-32

Note:

1. Total alpha should only be reported if radionuclide-specific information on alpha-emitters is not available.

Table 8-5: PRM Subsystem

Monitored Process	Sample Line or Detector Location	Monitoring Configuration
Isolation Condenser (IC) Leakage	Above IC Inner Pool A	Area
	Above IC Inner Pool B	Area
	Above IC Inner Pool C	Area
LWM Discharge	Upstream of discharge to CWS	Adjacent-to-Line
OGS Pre-Treatment	Upstream of the Charcoal Adsorber Vault	Offline (noble gas skid)
OGS Post-Treatment	Downstream of the Charcoal Adsorber Vault	Offline (noble gas skid)
OGS Charcoal Vault Ventilation	Charcoal Adsorber Vault Heating, Ventilation, and Air Conditioning system	Adjacent-to-Line
Gland Steam Condenser Exhaust	Upstream of the Continuous Exhaust Air Plenum (CEAP)	Adjacent-to-Line
Containment Inerting Exhaust	Upstream of the CEAP	Adjacent-to-Line
RB HVS Intake	Train A - Upstream of Lower Supply AHU	Adjacent-to-Line
	Train B - Upstream of Lower Supply AHU	Adjacent-to-Line
Lower RB HVS Exhaust	Prior to Combination with Refuel Floor/Fuel Pool Area HVS Exhaust (upstream of exhaust AHUs)	Adjacent-to-Line
Refuel Floor/Fuel Pool Area HVS Exhaust	Prior to combination with Lower RB HVS Exhaust (upstream of exhaust AHUs)	Adjacent-to-Line
TB HVS Exhaust	Upstream of Exhaust AHU set	Adjacent-to-Line
	Upstream of Exhaust AHU set	Adjacent-to-Line
PVS	At the PVS	Offline (PING skid)
CB HVS Intake	Upstream of Supply AHU Train A	Adjacent-to-Line
	Upstream of Supply AHU Train B	Adjacent-to-Line
	Downstream of CREEFU Train A	Adjacent-to-Line
	Downstream of CREEFU Train B	Adjacent-to-Line
RWB HVS Exhaust	Upstream of Exhaust AHUs	Adjacent-to-Line

Table 8-6: Monitoring Equipment - Containment Monitoring Subsystem

Containment Variable	Instrument Location
Pressure	Outside containment
Temperature	Inside containment
	Dome (x2)
	Support Skirt (x3)
	Under Vessel (x3)
	Level 0 (x2)
	Level -8.5 (x2)
	Level -21.0 (x2)
	Level -29.0 (x2)
	Level -34.0 (x2)
Water Level	Inside containment
Hydrogen and Oxygen Concentration	Outside containment
FP	Outside containment
Area Radiation Levels	Inside containment

Table 8-7: Process Sampling Subsystem - Automated Sample Panels

Panel	Process System	Line ID	Source Description
Reactor	Shutdown Cooling System (SDC)	G22-1	SDC Supply Flow Element (A)
		G22-2	SDC Supply Flow Element (B)
	Reactor Water Cleanup System (CUW)	G31-1	CUW Supply Flow Element
	Fuel Pool Cooling and Cleanup System (FPC)	G41-1	FPC Demineraliser Outlet
		G41-2	FPC Filter Inlet (A)
		G41-3	FPC Filter Inlet (B)
		G41-4	FPC Filter Outlet (A)
		G41-5	FPC Filter Outlet (B)
Turbine	Control Rod Drive System (CRD)	G12-1	CRD Pump Outlet
	Condensate and Feedwater Heating System (CFS)	N21-1	Condensate Filter Inlet
		N21-2	Final Feedwater (FW) Heater Outlet
	Condensate Filters and Demineralisers System (CFD)	N25-1	Condensate Demineraliser Outlet (Header)
		N25-2	Condensate Demineraliser Outlet (A)
		N25-3	Condensate Demineraliser Outlet (B)
		N25-4	Condensate Demineraliser Outlet (C)
		N25-5	Condensate Filter Outlet
	Main Condenser and Auxiliaries System (MCA)	N61-1	Main Condenser Outlet (Hotwell A)
		N61-2	Main Condenser Outlet (Hotwell B)
Radwaste	LWM	K10-1	Condensate Storage Tank (CST)
		K10-2	Ion Exchanger Outlet (A)
		K10-3	Ion Exchanger Outlet (B)
		K10-4	Polishing Ion Exchanger Outlet (A)
		K10-5	Polishing Ion Exchanger Outlet (B)
		K10-6	LWM Collection Tank (A)
		K10-7	LWM Tank (B)
		K10-8	LWM Sample Tank (A)
		K10-9	LWM Sample Tank (B)
		K10-10	Refueling Water Storage Tank (RWST) Inlet
		K10-11	Reverse Osmosis (RO) Outlet (A)
		K10-12	RO Outlet (B)
		K10-13	Sludge Consolidation Filter Inlet

Table 8-8: Process Sampling Subsystem - Local Grab Sample Stations

Station	Process System	Line ID	Source Description
1	Isolation Condenser Pools Cooling and Cleanup System (ICC)	G20-1	ICC Demineraliser Inlet
		G20-2	ICC Demineraliser Outlet
2	CFS	N21-3	Heater Drain (After FW Heat Exchanger (HX) 1A)
		N21-4	Heater Drain (Between FW HX 1A and 2A)
		N21-5	Heater Drain (Between FW HX 2 and 3)
		N21-6	Heater Drain (Between FW HX 3 and 4)
		N21-7	Heater Drain (Between FW HX 4 and 5)
		N21-8	Heater Drain (Between FW HX 5 and 6)
3	SWM	K20-1	High Integrity Container Dewatering Line
		K20-2	Sludge Storage Tank (A)
		K20-3	Sludge Storage Tank (B)
		K20-4	Spent Resin Storage Tank
		K20-5	Tank Dewatering Line
4	PCW	P40-1	PCW Pump Inlet
		P40-2	FPC HX Outlet (A)
		P40-3	FPC HX Outlet (B)
5	Equipment and Floor Drain System (EFS)	U50-1	Normal Sump
		U50-2	Pressurised Sump

Table 8-9: Process Sampling Subsystem Measurements

Sampled System When in Operation	Sample[1]	Typical Process Measurements[2]
CUW	C	Electrochemical potential, conductivity, dissolved oxygen, and dissolved hydrogen.
CUW	G	Chloride, sulfate, silica, TOC, Corrosion Product (CP) metals, zinc, boron, lithium, tritium, gross activity, activated CPs, FPs, and identified anions and cations (notably phosphate, fluoride, calcium, magnesium, and aluminium).
SDC when in service and plant cleanup has no flow for a required reactor water sample	C	Same as continuous and grab as reactor water sample above (CUW). Note only some of the instruments used, and sampling is not performed, due to plant mode during SDC.
CRD - Purge Water Pump Effluent	C	Local conductivity, dissolved oxygen.
CRD - Purge Water Pump Effluent	G	Local for troubleshooting.
FPC Influent	C	Conductivity, silica, and TOC.
FPC Influent	G	Chloride and sulfate.
FPC Effluent	C	Conductivity
FPC Effluent	G	Chloride, sulfate, TOC, silica, and CP metals.
Auxiliary Pools	G	Conductivity, others for troubleshooting or for activity as needed.
CST	C	Conductivity
CST	G	Chloride, sulfate, silica, TOC, post-UV anions, phosphate, nitrate, and gross activity.
MCA (Main Condenser Hotwell)	C	Conductivity, cation conductivity, or sodium in each hotwell depending on cooling water source.
CFS - Condensate	C	Conductivity, dissolved oxygen, weekly integrated CP metals.
CFS - Condensate	G	Chloride, sulfate, isotopics, post UV anions for troubleshooting.
CFD individual ion exchange effluent	C	Conductivity
CFD individual ion exchange effluent	G	Chloride, sulfate, isotopics, CP metals, and troubleshooting (silica, anions, cations).
Condensate (CFS) common effluent after CFD	C	Conductivity, oxygen (also as backup to FW), and weekly integrated metals.

Sampled System When in Operation	Sample[1]	Typical Process Measurements[2]
Condensate/FW – subsystem Heater Drain and Vent System (CFS)	G	Oxygen, iron, copper for troubleshooting.
		Heater 6 to 5
		Heater 5 to 4
		Heater 4 to 3
		Heater 3 to 1 and 2
		Heater 1 and 2 to hotwell or use hotwell sample.
FW (CFS) final FW	C	Conductivity, oxygen, hydrogen (also backup for CRD), and integrated metals.
FW (CFS) final FW	G	Zinc (if using IC), hydrogen flow rate (record from Hydrogen Water Chemistry system to plant computer). Post UV chlorides and sulfates troubleshooting.
OGS – pre-treat	C	Radioactivity including noble gases.
OGS – post-treat	G (Local Panel)	Tritium, iodine, particulates for gaseous release, and gaseous FP (N-13, Xe-133, Xe-135, Kr-m85, Kr-88, Kr-87, Xe-137, Xe-138, and Kr-89).
Liquid Radwaste – inlet (LWM)	C	Conductivity
Liquid Radwaste – inlet (LWM)	G	Chloride, sulfate, TOC, and silica.
Liquid Waste – Effluent Sample Tank (LWM)	C	(Gross Radioactivity only applicable if there is a liquid release), and conductivity.
Liquid Waste – Effluent Sample Tank (LWM)	G	Chloride, sulfate, silica, TOC, post-UV anions, phosphate, nitrate. Identification and concentration of principal radionuclide and alpha emitters. Regulator discharge requirement such as pH, suspended solids, oil and grease, iron, copper, and sodium nitrate if discharging to circulating water.
Liquid Radwaste Collection Tank (LWM)	C	Conductivity
Liquid Radwaste Collection Tank (LWM)	G	Chloride, sulfate, TOC, and gross activity.
RWST	C	Conductivity, others as needed.

Sampled System When in Operation	Sample[1]	Typical Process Measurements[2]
RWST	G	Chloride, sulfates, and TOC.
SWM – liquid portion if available	C	Gross radioactivity (only applicable if there is a liquid release). Grab – Identification and concentration of principal radionuclide and alpha emitters. Regulator Discharge Requirements such as pH, suspended solids, oil and grease, iron, copper, and sodium nitrate.
Boron Injection System	G	Grab – Percent by weight sodium pentaborate and pH.
ICC Influent	C	Conductivity
ICC Influent	G	Chlorides, sulfate, silica, and TOC as needed.
ICC Effluent	C	Conductivity
ICC Effluent	G	Chlorides, sulfate, TOC, and silica.
IC – pool water	G	Location to be determined, or sample from each of three pools as needed. Conductivity
PCW (may need for each loop)	C	Conductivity
PCW	G	Typically, this is utility specific. Conductivity, oxygen, metals, activity, and Minimum Inhibitory Concentration (MIC) sample. Corrosion inhibitor, biocide, and pH control as applicable to specific utility water treatment used.
Chilled Water Equipment	G	Local for MIC and biocide depending on specific utility water treatment method used.
EFS	G	Conductivity, TOC, cations and anions, and post UV anions as needed when troubleshooting sources to radwaste.
WGC – Demineralised Water	C	Continuous when in use for conductivity.
WGC – Demineralised Water Storage Tank	G	As needed, or get data from demineralised water plant (chloride, sulfate, post UV anions, silica, TOC, metals, phosphate, and nitrate).
CWS	G	This is utility specific based on environmental discharge permit and treatment. Typical analyses include free chlorine, pH, metals, chloride, sulfate, calcium, magnesium, and oil and grease.

Notes:

1 C is continuous process sampling. This can be either locally in the process stream or routed to a remote sample panel. G is a grab sample either locally from the process stream or a sample from a tank that is taken to the chemistry lab for analysis.

2 Location for both continuous and grab samples are routed to process sampling panel location (to be determined). Local means the continuous instrumentation is in the system process stream as is local grab sample.

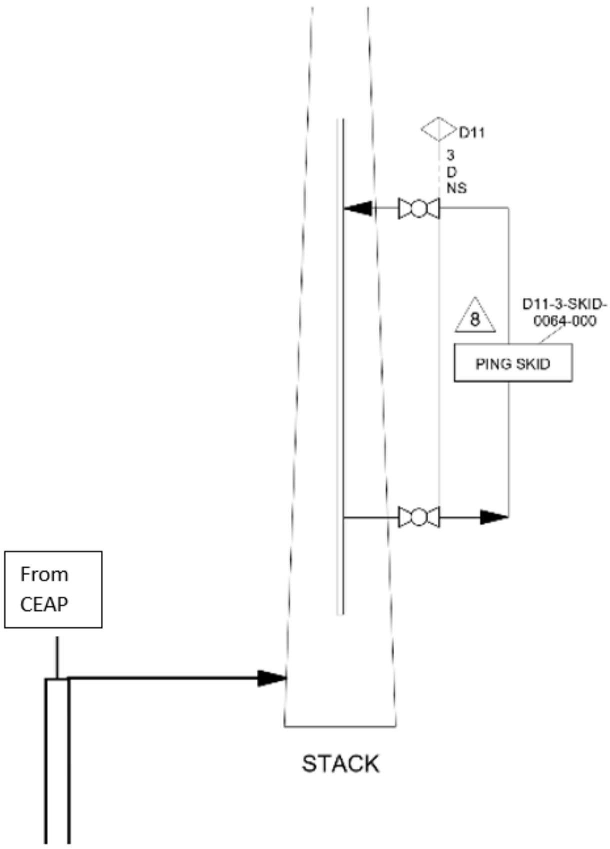

Figure 8-1: PVS Sampling Arrangement

(Extracted from 006N6319, PREMS facility diagram (Reference 8-34))

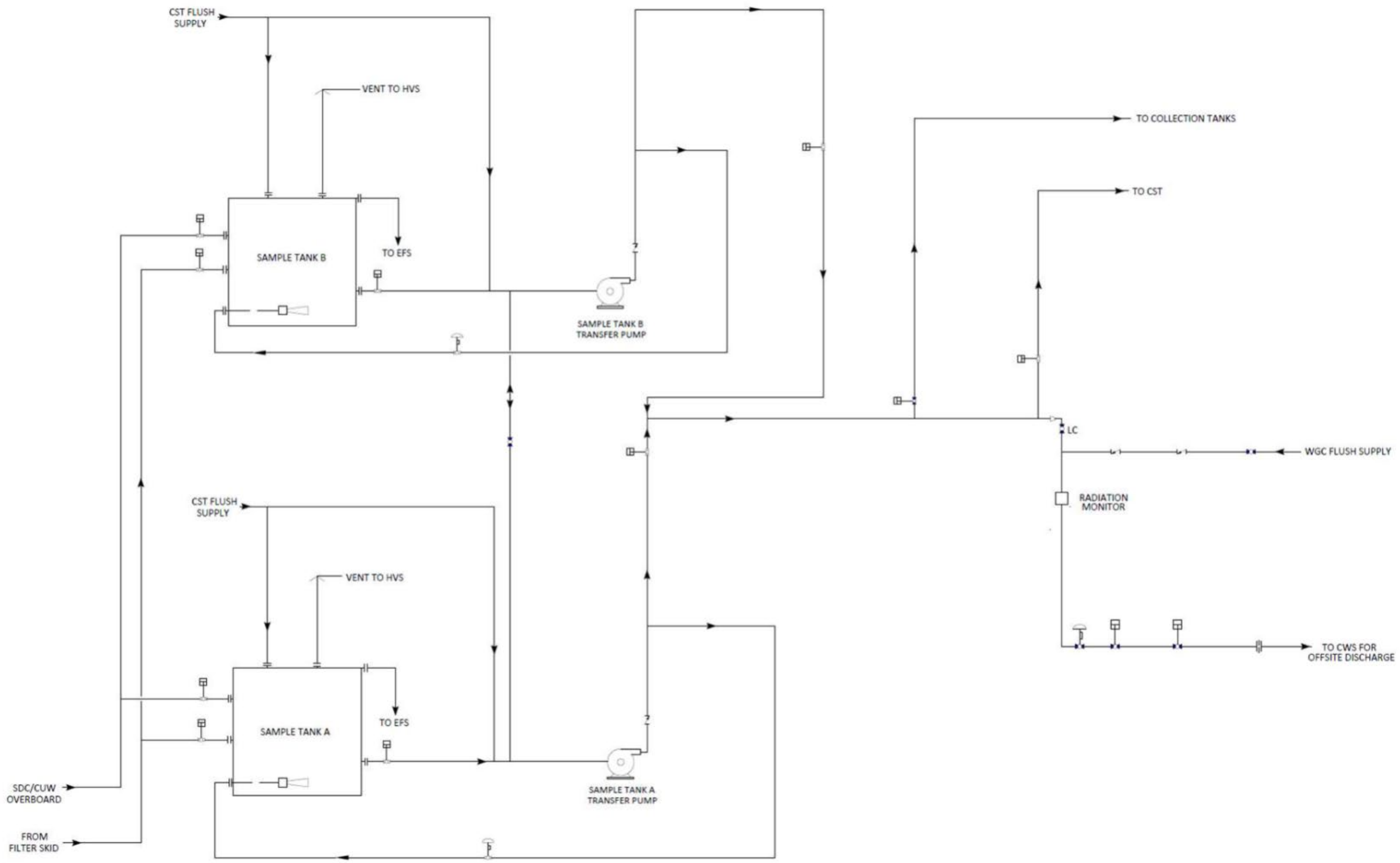

Figure 8-2: Waste Sampling Subsystem Simplified Diagram

(Extracted from 006N7729, LWM SDD (Reference 8-35))

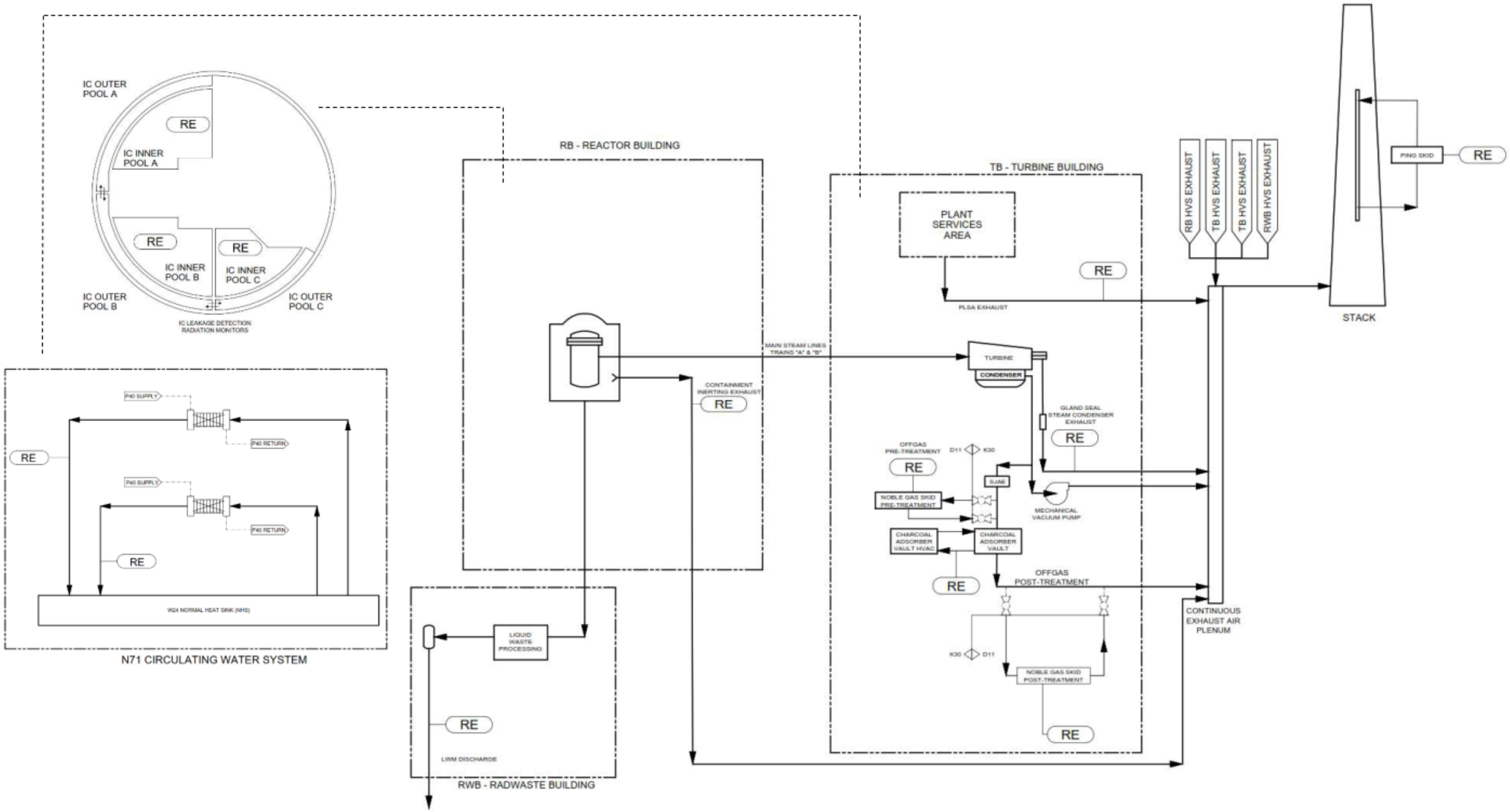

Figure 8-3: Process Radiation Monitoring Subsystem (Overview)

(Extracted from 006N7938, PREMS SDD (Reference 8-36))

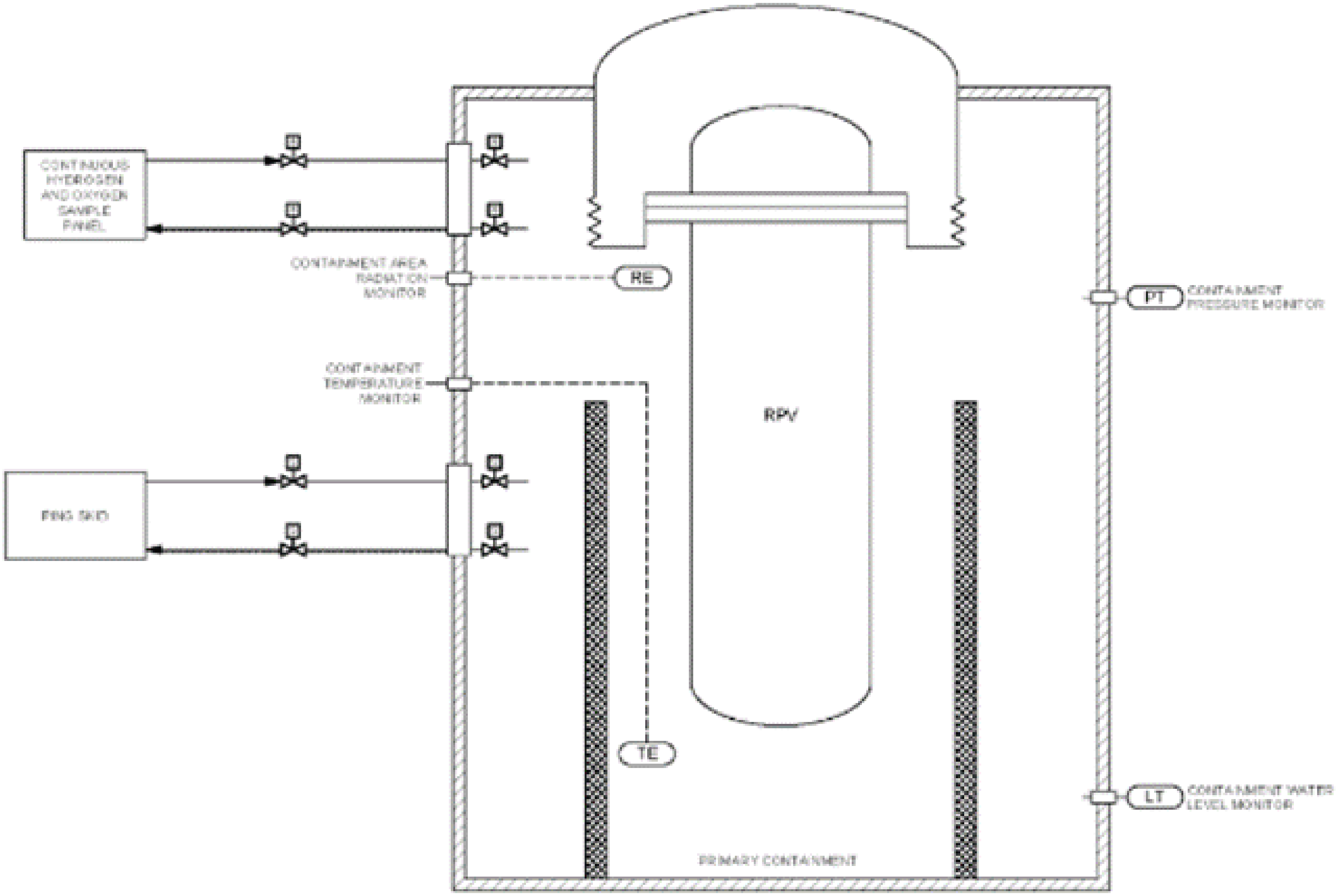

Figure 8-4: Simple Diagram of Containment Monitoring Subsystem

(Extracted from 006N7938, PREMS SDD (Reference 8-36))

8.7 References

8-1 006N7781, "BWRX-300 Heating, Ventilation, and Cooling System," GE-Hitachi Nuclear Energy, Rev 3, November 2023.

8-2 "The Environmental Permitting (England and Wales) Regulations 2016," (as amended), UK Government, Accessed September 2024.

8-3 NEDC-34223P, "BWRX-300 UK GDA Ch E6: Demonstration of Best Available Techniques Approach," Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

8-4 NEDC-34274P, "BWRX-300 UK GDA – Forward Action Plan," Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

8-5 NEDC-34221P, "BWRX-300 UK GDA Ch. E4: Information about the Design," Rev A, GE-Hitachi Nuclear Energy, Americas LLC.

8-6 NEDC-34222P, "BWRX-300 UK GDA Ch. E5: Radioactive Waste Management Arrangements," Rev A, GE-Hitachi Nuclear Energy, Americas LLC.

8-7 NEDC-34224P, "BWRX-300 UK GDA Ch. E7: Radioactive Discharges," Rev A, GE-Hitachi Nuclear Energy, Americas LLC.

8-8 NEDC-34226P, "BWRX-300 UK GDA Ch E9: Prospective Radiological Assessment," Rev A, GE-Hitachi Nuclear Energy, Americas LLC.

8-9 006N5377, "BWRX-300 Refueling and Servicing Equipment," GE-Hitachi Nuclear Energy, Rev 2, October 2023.

8-10 "Convention for the Protection of the Marine Environment of the North-east Atlantic," OSPAR Commission, 2007.

8-11 2008/1/EC, "Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control", European Commission, January 2008.

8-12 2013/59/Euratom, "Council Directive 2013/59/Euratom of 5 December 2013 Laying Down Basic Safety Standards for Protection Against the Dangers Arising from Exposure to Ionising Radiation, and Repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom," European Commission, December 2013.

8-13 2004/2/Euratom, "Commission Recommendation of 18 December 2003 on Standardised Information on Radioactive Airborne and Liquid Discharges into the Environment from Nuclear Power Reactors and Reprocessing Plants in Normal Operation," European Commission, 2004.

8-14 "Corrigendum to Commission Recommendation 2004/2/Euratom of 18 December 2003 on Standardised Information on Radioactive Airborne and Liquid Discharges into the Environment from Nuclear Power Reactors and Reprocessing Plants in Normal Operation," European Commission, 2004.

8-15 "Radioactive Substances Regulation: Objective and Principles," Environment Agency, December 2021.

8-16 "RSR Generic Developed Principles: Regulatory Assessment," Environment Agency, Updated May 2024.

8-17 "New Nuclear Power Plants: Generic Design Assessment Guidance for Requesting Parties," Environment Agency, Natural Resources Wales, Office for Nuclear Regulation, October 2023.

8-18 BS ISO 2889:2023, "Sampling Airborne Radioactive Materials from the Stacks and Ducts of Nuclear Facilities," British Standards Institute, July 2023.

8-19 ISO 10780:1994, "Stationary Source Emissions – Measurement of Velocity and Volume Flowrate of Gas Streams in Ducts," International Organization for Standardization, 1994.

8-20 BS EN60761-1:2004, "Radiation Protection Instrumentation – Equipment for Continuous Monitoring of Radioactivity in Gaseous Effluents. Part 1: General Requirements," British Standards Institution, 2004.

8-21 BS EN 60761-3:2004, "Equipment for Continuous Monitoring of Radioactivity in Gaseous Effluents – Part 3: Specific Requirements for Radioactive Noble Gas Monitors," British Standards Institution, 2004.

8-22 "Minimum Requirements for Self-monitoring of Flow: MCERTS Performance Standard," Environment Agency, August 2024.

8-23 "MCERTS Performance Standard for Radioanalytical Testing of Environmental and Waste Waters," Environment Agency, Version 4, August 2024.

8-24 BS EN ISO/IEC 17025:2017, "General Requirements for the Competence of Testing and Calibration Laboratories," British Standards Institution, 2018.

8-25 "Monitoring Stack Emissions: Measurement Locations," Environment Agency, 2022.

8-26 "Monitoring Stack Emissions: Standards for Continuous Monitoring and Sampling," Environment Agency, 2024.

8-27 "Monitoring Stack Emissions: Techniques and Standards for Periodic Monitoring," Environment Agency, 2022.

8-28 "Radiological Monitoring Technical Guidance Note 2, Environmental Radiological Monitoring," Environment Agency et. al., 2010.

8-29 007N1460, "BWRX-300 Annual Average Liquid Effluent Activity Releases," GE-Hitachi Nuclear Energy, Rev 3, May 2023.

8-30 DBR-0060900, "BWRX-300 Zero Release Plan," GE-Hitachi Nuclear Energy, Rev 2, September 2023.

8-31 007N1978, "Annual Average Gaseous Effluent Releases for the BWRX-300 Standard Plant," GE-Hitachi Nuclear Energy, Rev 2, June 2023.

8-32 STI/DOC/010/421, "Management of Waste Containing Tritium and Carbon-14," International Atomic Energy Agency, July 2004.

8-33 EPRI 1021106, "Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents," EPRI, December 2010.

8-34 006N6319, "BWRX-300 D11 Process Radiation and Environmental Monitoring System Facility Diagram", GE Hitachi Nuclear Energy, Rev 2, June 2022.

8-35 006N7729, "BWRX-300 Liquid Waste Management System," GE-Hitachi Nuclear Energy, Rev 1, March 2023.

8-36 006N7938, "BWRX-300 Process Radiation and Environmental Monitoring System," GE Hitachi Nuclear Energy, Rev 1, August 2023.

8-37 006N7899, "BWRX-300 Offgas System," GE-Hitachi Nuclear Energy, Rev 1, August 2023.

8-38 005N9751, "BWRX-300 General Description," GE-Hitachi Nuclear Energy, Rev F, December 2023.

8-39 006N7733, "BWRX-300 Solid Waste Management System," GE-Hitachi Nuclear Energy, Rev 1, April 2023.

8-40 "Solid Radioactive Waste Characterisation Good Practice Guide," Nuclear Decommissioning Authority, March 2022.

8-41 IAEA-TECDOC-1537, "Strategy and Methodology for Radioactive Waste Characterization," International Atomic Energy Agency, March 2007.

8-42 DEPWMP48-TR05, "Characterisation Good Practice Model," Nuclear Waste Services, Issue 1, March 2024.

8-43 DBR-0060012, "BWRX-300 Water Chemistry Sampling and Monitoring," GE-Hitachi Nuclear Energy, Rev 1, May 2023.

8-44 DBR-0070157, "Design Basis of Process Sample Panels," GE-Hitachi Nuclear Energy, Rev 0, April 2024.

8-45 008N0988, "BWRX-300 Power Block PSAR General Arrangement," GE-Hitachi Nuclear Energy, Rev 2, September 2023.

8-46 007N3673, "Chemistry Laboratory Requirements," GE-Hitachi Nuclear Energy, Rev 1, February 2024.

8-47 NEDC-34141P, BWRX-300 UK GDA "Environmental Strategy," Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

8-48 RIFE 28, "Radioactivity in Food and the Environment", 2022.

APPENDIX A SAMPLING AND MONITORING FORWARD ACTION PLAN

Table A-1: Forward Action Plan

Unique Code1	Source	Finding	Forward Actions	Lead Discipline	Delivery Phase
PER6-306	PER Chapter E6 Section 6.2.14	Currently there is no methodology for the assignment of EPFs to SSC.	Develop the outline methodology for identifying and assigning EPFs to SSC during GDA Step 2 and include in an update to PER Chapter E6 Note: detailed methods development and performance of analysis will be in a later licensing phase.	Environment - Demonstration of BAT Approach	Within Step 2
PER8-206	PER Chapter 8 Section 8.2.1	The significant radionuclides discharged from the gaseous and aqueous liquid systems have not yet been fully identified. This is required to enable suitable sampling and monitoring equipment to be selected.	Refine BWRX-300 EUST for gaseous and aqueous liquid radioactive discharges so that it includes radionuclides listed in the 2004/2/Euratom recommendation. Determine the significant radionuclides that require sampling and monitoring in the radioactive discharges.	Environment – Sampling and Monitoring	For PCSR/Pre-Construction Environmental Report (PCER)
PER8-207	PER Chapter 8 Section 8.6	The UK environmental regulator needs to be able to independently undertake sampling of the gaseous and aqueous liquid discharges. Independent sampling facilities are not included in the current BWRX-300 design.	The facility for independent sampling needs to be included in the design of the BWRX-300. This requirement will need to be BAT. The requirement will need to ensure that it meets UK regulatory requirements and standards (identified in Section 8.1.3).	Environment – Sampling and Monitoring	For PCSR/PCER
PER8-208	PER Chapter 8 Section 8.6	It is unclear if there is sufficient space (as per UK guidance/standards) around the discharge sampling locations to facilitate safe independent sampling in addition to the sampling included in the current BWRX-300 design.	When designing the facility for independent sampling, ensure that suitable space requirements are included.	Environment – Sampling and Monitoring	For PCSR/PCER

Unique Code1	Source	Finding	Forward Actions	Lead Discipline	Delivery Phase
PER8-209	PER Chapter 8 Section 8.2.2, 8.3, and 8.4.1	Sampling and monitoring equipment has not yet been selected other than for the functional requirements.	Selection of sampling and monitoring equipment should be delayed as late as possible to ensure that the most suitable equipment available at the time can be selected (and that early selection does not foreclose any options). Selected sampling and monitoring equipment must be BAT at the time of selection. Selected equipment must meet the regulatory standards (e.g., MCERTS).	Environment – Sampling and Monitoring	For Site License Application
PER8-211	PER Chapter 8 Section 8.4.5	The solid waste (ILW/ High Activity Waste) characterisation requirements cannot be fully established at Step 2 GDA. This requires detailed information on the wastes.	The owner/operator will need to develop detailed solid waste characterisation plans.	Environment – Sampling and Monitoring	For Site License Application
PER8-212	PER Chapter 8 Section 8.5	The BAT case for sampling and monitoring at GDA Step 2 is limited to claims and arguments.	The BAT case will be fully developed through synthesis of evidence to underpin the arguments presented at GDA Step 2.	Environment – Sampling and Monitoring	For PCSR/PCER
PER8-213	PER Chapter 8 Section 8.4.7	Although an on-site laboratory is detailed, it is still to be determined what range of samples are to be analysed, limits of detection required, accreditation, and if off-site laboratory support is needed.	Laboratory requirements are to be determined.	Environment – Sampling and Monitoring	For Site License Application

Unique Code1	Source	Finding	Forward Actions	Lead Discipline	Delivery Phase
PER8-214	PER Chapter 8 Section 8.1.3	As the site is only generic, no boundary, off-site, or GW monitoring has been designed.	Designs are required for: • Boundary monitoring • GW monitoring • Off-site monitoring (to meet “Radioactivity in Food and the Environment” (RIFE 28), requirements (Reference 8-48)).	Environment – Sampling and Monitoring	For Site License Application
PER8-310	PER Chapter 8 Section 8.2.2	The current BWRX-300 design does not include a flowmeter for determining the volume discharges from the PVS.	A flow meter that measures the continuous gaseous discharge flow from the PVS is required to be incorporated into the design. The design will be required to meet the UK regulations, standards, and guidance.	Environment – Sampling and Monitoring	For Site License Application
PER8-311	PER Chapter 8 Section 8.4.1	Final locations for sampling and monitoring equipment have not yet been selected.	Final locations of sampling and monitoring equipment should be delayed as late as possible to ensure that the most suitable positions can be selected (and early selection does not foreclose any options). Locations must be BAT at the time of selection.	Environment – Sampling and Monitoring	For Site License Application

Note:

1. The unique code is taken from the GDA Commitments and Actions Register.