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 (radioactivity and volume)
- 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
- 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. The design maturity of the BWRX-300 Standard Design presented at GDA Step 2 is not sufficiently developed to provide detailed information on the sampling and monitoring provision. However, a pathway to future fulfilment of UK requirements for final discharge accountancy is described.

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 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
ALARA	As Low As Reasonably Achievable
ALARP	As Low As Reasonably Practicable
ARM	Area Radiation Monitoring Subsystem
BAT	Best Available Techniques
BL3	Baseline 3
BS	British Standard
BWR	Boiling Water Reactor
CAE	Claims, Arguments, Evidence
CB	Control Building
CEAP	Continuous Exhaust Air Plenum
CFD	Condensate Filters and Demineralisers System
CFS	Condensate and Feedwater Heating System
CMon	Containment Monitoring Subsystem
CNSC	Canadian Nuclear Safety Commission
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
DRP	Design Reference Point
EA	Environment Agency
EFS	Equipment and Floor Drains System
EIMT	Examination, Inspection, Maintenance, and Testing
ENDP	Engineering Developed Principle
EPF	Environment Protection Function
EPM	Environment Protection Measure
EPR	Environmental Permitting Regulations
EUST	End User Source Term
FAP	Forward Action Plan

Acronym	Explanation
FOAK	First of a Kind
FP	Fission Product
FPC	Fuel Pool Cooling and Cleanup System
FSF	Fundamental Safety Function
FW	Feedwater
GDA	Generic Design Assessment
GEH	GE-Hitachi Nuclear Energy Americas, LLC
GW	Groundwater
HEPA	High Efficiency Particulate Air
HVS	Heating, Ventilation and Cooling System
HX	Heat Exchanger
IAEA	International Atomic Energy Agency
IC	Isolation Condenser
ICC	Isolation Condenser Pools Cooling and Cleanup System
ICRP	International Commission on Radiological Protection
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
MVP	Mechanical Vacuum Pump
NRC	Nuclear Regulatory Commission
NRW	Natural Resources Wales
OGS	Offgas System
OPEX	Operational Experience
PCSR	Pre-Construction Safety Report
PCW	Plant Cooling Water System
PER	Preliminary Environmental Report
PING	Particulate, Iodine and Noble Gas
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

Acronym	Explanation
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
SSC	Structure, System, and Component
SWM	Solid Waste Management System
TB	Turbine Building
TGSS	Turbine Gland Seal Subsystem
TOC	Total Organic Carbon
UK	United Kingdom
U.S.	United States of America
WGC	Water, Gas, and Chemical Pads

SYMBOLS AND DEFINITIONS

Symbol	Definition
Bq	Becquerel
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)

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REVISION SUMMARY

Revision #	Section Modified	Revision Summary
A	All	Initial Issuance
B	All	Update for end of GDA Step 2 consolidation

8 APPROACH TO SAMPLING AND MONITORING

Introduction

The GEH BWRX-300 is a Boiling Water Reactor (BWR) that is designed as a Small Modular Reactor. At GDA Step 2, a single BWRX-300 unit of 300-Megawatt electric (MWe) capacity is presented, located on a coastal site.

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 and the Advanced Boiling Water Reactor (ABWR).

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.

This document is a chapter within the Preliminary Environmental Report (PER), which forms the main part of the Environment Case.

BWRX-300 Design Concept and Philosophy

The First of a Kind (FOAK) BWRX-300 design is being developed in the United States of America (U.S.) for international deployment using a Standard Design approach to minimise the design variation from project to project. A phased design process based on Requirements Management has been adopted, as described in NEDO-34220, “BWRX-300 UK GDA Chapter E3: Management Arrangements and Responsibilities,” (Reference 8-1). A hierarchical flow of design requirements, from ‘source’ top-level legislative and regulatory requirements through to plant, system, and component levels, places constraints on the plant design to ensure that the final design fulfils all source requirements via logical and traceable decision-making processes.

The design requirements for the BWRX-300 Standard Design are based on recommendations and safety standards established by the International Atomic Energy Agency (IAEA), the International Commission on Radiological Protection (ICRP), the U.S. Nuclear Regulatory Commission (NRC), and the Canadian Nuclear Safety Commission (CNSC) (see GEH Requirements Specification document 006N5081, “BWRX-300 As Low As Reasonably Achievable Design Criteria for Standard Design,” (Reference 8-2)). This document is an ‘A level’ document that allocates and enforces requirements for radiation protection, to reduce occupational and public exposure to radiation to levels that are As Low As Reasonably Achievable (ALARA).[1]

Aligned with the high-level ALARA Objectives and requirements presented in “BWRX-300 As Low As Reasonably Achievable Design Criteria for Standard Design,” (Reference 8-2), 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 (radioactivity and volume)

[1] The ALARA approach adopted by GEH in the BWRX-300 design is based on international regulations and standards (e.g., ICRP Publication 103, “The 2007 Recommendations of the International Commission on Radiological Protection,” (Reference 8-3) and IAEA General Safety Requirements GSR Part 3, “Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards,” (Reference 8-4)), as distinct from the specific implementation of the ALARA requirement in UK environmental legislation and regulatory guidance.

- Treating/abating any radioactive waste generated so that it is concentrated/contained or minimised before release to the environment

Purpose

The purpose of this PER chapter is to describe the sampling and monitoring of radioactive gaseous and aqueous liquid 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 radioactive wastes. Throughout this chapter, the terms “sampling” and “monitoring” are used according to the following definitions:

- Sampling – collection of a representative sample, that is analysed at a location remote from the sampling point. Results are obtained a period of time after the sample was taken
- Monitoring – real-time monitoring of the parameter/condition of interest. Results are obtained immediately

Design Maturity

The BWRX-300 Standard Design presented at GDA Step 2 is at a level of development defined by the Design Reference Point (DRP) described in NEDC-34154P, “BWRX-300 UK GDA Design Reference Report,” (Reference 8-5). The design maturity at the DRP is not sufficiently developed to provide detailed information on the sampling and monitoring provision, which must be tailored to local regulatory and reporting requirements for each country-specific BWRX-300 project. However, GEH is confident that the BWRX-300 design, based on 60 years of design evolution and OPEX, will be compatible with the taking of representative samples to meet UK final discharge accountancy requirements. A robust approach to Requirements Management and the capture of future work required beyond GDA Step 2 in a Forward Action Plan (FAP) is considered to provide a pathway to meeting UK compliance requirements in addition to minimising the risk of foreclosure of options during the design process. The final selection of equipment and locations for sampling and monitoring will be subject to demonstration of Best Available Techniques (BAT) by a future developer/operator.

Scope

This chapter presents the following high-level 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 radioactive 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 BAT for permitting, to demonstrate that optimisation to the ALARA requirements of "The Environmental Permitting (England and Wales) Regulations 2016," (as amended) (EPR16) (Reference 8-6) 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 NEDO-34223, "BWRX-300 UK GDA Chapter E6: Demonstration of Best Available Techniques Approach," (Reference 8-7). BAT claims and arguments relating specifically to sampling and monitoring arrangements are presented in Section 8.6 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 BWRX-300 reactor. The available technology may progress on these timescales, and the relevant UK requirements for sampling and monitoring may change. Therefore, it is not appropriate to specify actual instrumentation at this time, as to do so may result in foreclosure of options. 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 monitoring requirements or provision for sample collection (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

This chapter presents a level of detail commensurate with a two-step GDA. A 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[3] are presented in NEDC-34274P, "BWRX-300 UK GDA – Forward Action Plan," (Reference 8-8), in addition to a copy of the reviewed and accepted central FAP register at the start of GDA Step 2.

Document Structure

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

Section 8.1 Regulatory Context

Section 8.2 Final Discharge Accountancy

Section 8.3 Safety Categorisation and Classification

Section 8.4 Examination, Inspection, Maintenance, and Testing

Section 8.5 System and Equipment Design

Section 8.6 Demonstration of BAT (Claims and Arguments)

Section 8.7 Independent Sampling and Monitoring

[3] Any remaining FAP items in this category are expected to be closed out prior to GDA Step 2 exit.

Interfaces with other Chapters

This chapter interfaces with the following chapters within the PER:

- PER Chapter E3 (Reference 8-1)
- NEDO-34221, “BWRX-300 UK GDA Chapter E4: Information about the Design,” (Reference 8-9)
- NEDO-34222, “BWRX-300 UK GDA Chapter E5: Radioactive Waste Management Arrangements,” (Reference 8-10)
- PER Chapter E6 (Reference 8-7)
- NEDO-34224, “BWRX-300 UK GDA Chapter E7: Radioactive Discharges,” (Reference 8-11)
- NEDO-34226, “BWRX-300 UK GDA Chapter E9: Prospective Radiological Assessment,” (Reference 8-12)

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

8.1 Regulatory Context

GEH has entered the GDA process up to Step 2 with the BWRX-300 design. 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 8-6).

A further requirement on sites with an EPR permit in England and Wales is that BAT is used for sampling and monitoring of radioactive 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 8-13) 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 8-14). Further information on GEH's approach to assessing and demonstrating BAT is provided in PER Chapter E6 (Reference 8-7).

8.1.1.1 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 8-15), 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 8-16) 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 8-17).

The 2004/2/Euratom document (Reference 8-16) 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 8-18) and "RSR generic developed principles: regulatory assessment," (Reference 8-19) documents. The requirements relating to sampling and monitoring arrangements, techniques, and systems for measurement and assessment of radioactive discharges, and disposals of radioactive waste, are reproduced below, in accordance with the guidance (Reference 8-19).

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."

Outline methodology for identifying and assigning Environment Protection Functions (EPFs) for the BWRX-300 within the UK to demonstrate appropriate environment protection is presented in NEDC-34347, "BWRX-300 UK GDA Environment Protection Function Methodology," (Reference 8-20).

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."

ENDP11 – maintenance, inspection and testing

"Structures, systems and components that are, or comprise part of, environment protection measures should receive regular and systematic examination, inspection, maintenance and testing."

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 8-21). 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 8-16) are presented in Section 8.1.1.1.

8.1.3 Standards

The following standards are relevant to the development of the BWRX-300 sampling and monitoring 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.

8.1.3.1 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 8-22). 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.

8.1.3.2 ISO 10780:1994

ISO 10780:1994, "Stationary source emissions – Measurement of velocity and volume flowrate of gas streams in ducts," (Reference 8-23), 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.

8.1.3.3 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 radioactivity in gaseous effluents. BS EN60761-1:2004, "Radiation protection instrumentation – Equipment for continuous monitoring of radioactivity in gaseous effluents. Part 1: General requirements," (Reference 8-24) focuses on the general requirements of continuous monitoring, of which there is some overlap with BS ISO 2889:2023 (Reference 8-22). 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 8-25)).

8.1.3.4 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 8-26). 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 8-26)
- EA: "MCERTS performance standard for radioanalytical testing of environmental and waste waters," (Reference 8-27)
- British Standards Institution: BS EN ISO/IEC 17025:2017 "General requirements for the competence of testing and calibration laboratories," (Reference 8-28)
- EA: "Monitoring stack emissions: measurement locations," (Reference 8-29)
- EA: "Monitoring stack emissions: standards for continuous monitoring and sampling," (Reference 8-30)
- EA: "Monitoring stack emissions: techniques and standards for periodic monitoring," (Reference 8-31)

GEH note that there is guidance on environmental monitoring available from the environmental regulators ("Radiological monitoring technical guidance note 2, Environmental radiological monitoring," (Reference 8-32)) 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, in addition to GW and off-site monitoring.

FAP.PER8-214 – When site-specific information is available, the future developer/operator shall define programmes for implementation and documentation of:

- **Boundary monitoring**
- **GW monitoring**
- **Off-site monitoring (to meet RIFE 28, "Radioactivity in food and the environment," (Reference 8-33) requirements)**

8.2 Final Discharge Accountancy

8.2.1 Capture of UK Requirements

The FOAK BWRX-300 design is being developed in the U.S. for international deployment using a Standard Design approach to minimise the design variation from project to project. A phased design process based on Requirements Management has been adopted, as described in PER Chapter E3 (Reference 8-1). This hierarchical flow of requirements and decision-making, from top-level legislative and regulatory requirements through to plant, system, and component levels, ensures that a logical design process is followed that maximises flexibility and avoids foreclosure of options.

The design requirements for the BWRX-300 Standard Design are based on recommendations and safety standards established by the IAEA and the ICRP, U.S. NRC, and CNSC ("BWRX-300 As Low As Reasonably Achievable Design Criteria for Standard Design," (Reference 8-2)). As such, UK-specific requirements do not comprise the design basis of the generic BWRX-300 design under assessment at GDA Step 2. It is anticipated that GEH's Requirements Management process will guide the specification of plant and equipment for sampling and monitoring provision for a BWRX-300 installation in the UK, at the Baseline 3 (BL3) (site-specific) design development stage.

FAP.PER8-337 – UK requirements for sampling and monitoring shall be inserted into the BWRX-300 Requirements Management process at design BL3 for UK site-specific design development.

Experience of previous GDAs and permitting programmes, combined with engagement with the UK regulators during the GDA process has facilitated identification of UK requirements for sampling and monitoring provision, which will be incorporated into the BWRX-300 design at the appropriate development phase. Without prejudice to the future requirements capture process, GEH acknowledges that such requirements will need to address the following:

- Any sampling or monitoring location should:
    - Have sufficient room:
        - To accommodate the sampling/monitoring equipment
        - To accommodate any staff access requirements (or equipment must be recoverable/replaceable by remote means)
        - To avoid interference between different sampling and monitoring systems
- Provision must be made for independent sampling and monitoring by the regulator (or their representative)
    - Sufficient space and access provision must be included in the plant design
- Representative sample collection:
    - Minimisation of settling out or plating in sample transfer pipes:
        - Sample lines should be as short as possible
        - Bends should be minimised
        - Temperature changes should be avoided
        - Sample lines should be constructed of suitable materials
    - The proportion of the subsample relative to the final discharge must be measured
    - Need for laminar flow conditions in gaseous and aqueous systems

    - Need to exclude particulate from gaseous systems

- Gaseous discharge of carbon-14 should be measured through sampling and analysis rather than calculation
    - Sufficient space and access provision for carbon-14 sampling and analysis must be included in the plant design
- Tritium in aqueous liquid discharges should be sampled and analysed as part of the final discharge accountancy
- Sampling and monitoring equipment must:
    - Be added to a suitable Examination, Inspection, Maintenance, and Testing (EIMT) regime/schedule
    - Meet relevant UK regulatory standards (e.g., MCERTS)
- Compliance with 2004/2/Euratom reporting recommendations

Application of UK-specific requirements to the BWRX-300 Standard Design using Requirements Management will provide a pathway to incorporation of sampling and monitoring provision to meet UK compliance requirements as part of an overall optimisation process, when combined with resolution of relevant FAP items and site-specific information. This approach is anticipated to allow relevant plant design features to be incorporated, and suitable equipment selected, at the most appropriate time during the BWRX-300 design development process, minimising the risk of options being foreclosed either by premature or late consideration. Holistic treatment of design requirements at the site-specific stage will allow, for example:

- Parallel development of operator and independent sampling and monitoring systems, thereby minimising the risk of incompatibility
- Parallel consideration of space requirements for equipment (sampling, monitoring, and flow measurement) and access requirements for EIMT activities
- Parallel consideration of the laminar flow conditions needed in the Plant Vent Stack (PVS) for representative sampling, and other factors such as dispersion modelling studies and engineering considerations

8.2.2 Management Arrangements for Sampling and Monitoring

In addition to the requirements capture process detailed in Section 8.2.1, it is acknowledged that appropriate management arrangements will also need to be developed to support the BWRX-300 sampling and monitoring regime in order to:

- Ensure compliance with final discharge accountancy and reporting requirements
- Ensure compliance with environmental monitoring requirements
- Inform strategy for management of radioactive wet solid wastes
- Monitor plant performance to identify any deviation from the normal operating state, and determine whether equipment identified as BAT is performing as expected

FAP.PER8-379 - A future developer/operator shall develop a detailed sampling, monitoring, and characterisation programme in order to determine final discharge accountancy and solid waste inventory, and monitor plant/system performance, including a suitable record-keeping system.

8.2.3 Parameters to be Measured (Final Discharges)

8.2.3.1 Radionuclides

In 2004/2/Euratom (Reference 8-16), the key radionuclides are listed as in Table 8-1 and Table 8-2 (see Section 8.1.1.1). Based on the current End User Source Terms (EUSTs) for BWRX-300 radioactive discharges (see PER Chapter E7 (Reference 8-11)), the radionuclides with the greatest radioactivity (Bq/y) are:

- Noble gases, tritium, and carbon-14 for radioactive gaseous discharges
- Tritium for radioactive aqueous liquid discharges[4]

Based on the assessments undertaken in PER Chapter E9 (Reference 8-12) the radionuclides with the largest contribution of radiological 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 radioactive gaseous discharges
- Cobalt-60, zinc-65, and phosphorus-32 for radioactive aqueous liquid discharges

It should be noted that the BWRX-300 is capable of being operated under normal operating conditions with maximum recirculation[5] of process water, minimising the need to make radioactive aqueous liquid discharges to the environment (see PER Chapter E7 (Reference 8-11) and GEH's Design Basis Record (DBR) document DBR-0060900, "BWRX-300 Zero Release Plan," (Reference 8-34)). However, occasional radioactive 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 radioactive gaseous and aqueous liquid discharges of the BWRX-300. PER Chapter E7 (Reference 8-11) discusses the current limitations of the EUST for radioactive discharges. A list of the 2004/2/Euratom radionuclides that are not included in the BWRX-300 radioactive discharge assessments at GDA Step 2 is provided in PER Chapter E7, Table 7-4.

The fact that the 2004/2/Euratom significant radionuclides have not yet been fully identified is recognised as a component of forward action **FAP.PER7-196**, raised in PER Chapter E7 (Reference 8-11).

FAP.PER7-196 – *"The Primary Source Term and End User Source Term data for radioactive gaseous and aqueous liquid discharges from the BWRX-300 shall be refined, taking into account:*

- *Anticipated Operational Occurrences with environmental consequences (see **FAP.PER5-110**)*
- *The 2004/2/Euratom reporting recommendations*
- *A review of the assumptions and calculation methodologies to be used, with consideration of relevant OPEX available at the time*
- *Consideration of the use of sensitivity analysis to inform prioritisation of effort for ongoing design optimisation*

[4] Tritium is excluded from GEH's assessment of the radioactivity of radioactive aqueous liquid discharge presented in 007N1460, "BWRX-300 Annual Average Liquid Effluent Activity Releases," (Reference 8-35). The bounding case for discharge of tritium via the aqueous liquid pathway for the BWRX-300 is presented in PER Chapter E7 (Reference 8-11), based on the assumptions stated therein.
[5] The decision to operate with maximum recirculation or periodic radioactive aqueous liquid discharges will be the responsibility of the future developer/operator, who must consider both environmental and operational impacts.

This will allow more realistic updated radioactive discharge assessments to be produced. These data shall include estimates of:

- *Total radioactive gaseous and aqueous liquid discharges (final discharges)*
- *Radioactive disharges by route/source*
- *The impact on anticipated radioactive discharges of:*
  - *Different plant operational modes (e.g., startup and refuelling outages)*
  - *Expected events (e.g., a fuel pin failure)*
  - *Short-term releases (e.g., containment purging)*

These data shall then be used to:

- *Establish discharge limits, and enable the radiological dose assessment to be performed at the proposed limits*
- *Determine headroom factors*
- *Generate monthly and rolling monthly discharge assessments of the proposed operating cycle*
- *Determine the significant radionuclides that require sampling and monitoring in the radioactive discharges, such that suitable sampling and monitoring equipment can be selected."*

Radioactive 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 8-36), and "BWRX-300 Annual Average Liquid Effluent Activity Releases," (Reference 8-1), respectively.

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 sampling and monitoring system (on the PVS) is provided in GEH's document 006N6319, "BWRX-300 D11 Process Radiation and Environmental Monitoring System (PREMS) Facility Diagram," (Reference 8-37) and Section 8.5.3.

The information on sampling and monitoring of radioactive aqueous liquids prior to discharge is provided in the relevant GEH System Design Description (SDD) documents, 006N7729, "BWRX-300 Liquid Waste Management System," (LWM) (Reference 8-38) and the PREMS SDD 006N7938, "BWRX-300 Process and Radiation Monitoring," (Reference 8-39), and in Section 8.5.4 of this chapter.

8.2.3.2 Discharge Flows

To be able to report accurately the discharge of radioactive waste from release points, the volumetric flow of both gaseous and aqueous liquid discharge streams needs to be continuously measured using an appropriate MCERTS accredited technique (see MCERTS performance standard (Reference 8-26)).

8.2.3.2.1 Radioactive Gaseous Discharge Flows

The type and location of a flow meter(s) for radioactive gaseous discharges have not yet been incorporated into the BWRX-300 design. GEH acknowledges that provision of a flow meter to determine the volume of radioactive gaseous discharges from the PVS is a UK requirement (see Section 8.2.1).

FAP.PER8-310 - A flow meter that measures the continuous radioactive gaseous discharge flow from the PVS shall be incorporated into the BWRX-300 design for a site-specific installation in the UK.

The design will be required to meet the UK regulations, standards, and guidance.

8.2.3.2.2 Radioactive Aqueous Discharge Flows

The BWRX-300 design has a flow meter included in the radioactive aqueous liquid discharge pipe from the LWM Sample Tanks to the Circulating Water System (CWS) (and thereby to the marine environment) (PREMS facility diagram (Reference 8-37) and LWM SDD (Reference 8-38)). This arrangement is described in Section 8.5.4.

8.2.3.2.3 Equipment for Measurement of Flow

Sampling and monitoring equipment and the precise positioning of such equipment within the BWRX-300 design has not yet been selected other than for functional requirements and indicative purposes, as a result of:

- The design maturity of the BWRX-300 Standard Design at the DRP for GDA Step 2
- The need to consider UK-specific requirements at the site-specific development stage
- The time that may elapse between GDA and site-specific licencing/permitting
- The risk of foreclosure of options if equipment is selected prematurely

Therefore the actual flow meter type(s) has not been selected at GDA Step 2. The selection of sampling and monitoring equipment is for the future developer/operator to determine. It is recognised that any selected flow equipment will be required to meet MCERTS standards and be demonstrated to be BAT.

FAP.PER8-209 - The future developer/operator shall select sampling and monitoring equipment and the corresponding locations at the most appropriate stage of UK site-specific design development.

Selection of equipment and sampling/monitoring locations should be:

- **Delayed as late as possible to prevent foreclosure of options through early selection. This ensures that the most suitable equipment available at the time can be selected, and the most suitable locations identified**
- **Considered holistically in terms of overall design development, to prevent foreclosure of options for sampling and monitoring through plant architecture and relevant system design (e.g., lack of sufficient space, lack of capability for representative sampling, etc.)**

Selected sampling and monitoring equipment and locations shall:

- **Be demonstrably BAT at the time of selection**
- **Meet the relevant regulatory standards (e.g., MCERTS)**

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 the PREMS SDD (Reference 8-39).

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 (see NEDC-34161P, “BWRX-300 UK GDA Comparison of BWRX-300 Approach to Categorization & Classification with UK Expectations,” (Reference 8-40).

8.4 Examination, Inspection, Maintenance, and Testing

It is recognised that some of the sampling and monitoring equipment used on the BWRX-300 will be part of the Environment Protection Measures (EPMs) used to support BWRX-300 EPFs. It is a UK regulatory expectation that the means of safe access to Structures, Systems, and Components (SSCs) relating to EPFs is considered in the design as well as the necessary utilities (such as power) to enable future operators to undertake necessary EIMT tasks on the sampling and monitoring systems, as set out in ENDP11 (see Section 8.1.2). Outline methodology for identifying and assigning EPFs and EPMs for the BWRX-300 is presented in GEH's EPF methodology document (Reference 8-20), and this methodology will need to be implemented for UK deployment of the BWRX-300. Implementation of the EPF methodology will ensure that sampling and monitoring equipment which is identified to provide an EPF is added to a maintenance schedule and is managed to maintain its anticipated function as an EPM in line with ENDP11.

FAP.EPF-335 – "*The Environment Protection Function (EPF) methodology will need to be implemented for the UK deployment of the BWRX 300. Work is required to:*

- *Develop or review the quality management system to identify where there should be consideration of environmental impacts and specifically where there is an interface with EPFs*
- *Undertake hazard identification to identify all potential sources of radiological risk to people and the environment*
- *Identify and develop a list of EPFs and EPMs required to protect against the impact of identified radiological risks to people and the environment*
- *Develop an appropriate classification method for classification of EPMs providing the EPFs*
- *Record EPFs and EPMs on a relevant register, to be determined by the future operating organisation, and integrate into an asset management regime*
- *Integrate EPMs that provide an EPF into control and management arrangements*

To ensure an effective handover of the EPF methodology, training and familiarisation should be provided by the RP to the future operating organisation."

The BWRX-300 Standard Design at the DRP for GDA Step 2 has been developed with consideration of EIMT activities. As outlined in GEH's Plant Specification document 006N4173, "BWRX-300 Composite Design," (Reference 8-41), the BWRX-300 SSCs are designed to facilitate operation and maintenance. An understanding of necessary maintenance tasks provides vital input to SSC layout within the plant such that adequate access, workspace, and supporting utilities can be provided. Early identification of required SSC EIMT activities is important to enable the parallel design of the physical plant structure, and design of SSCs required to function within the plant. The BWRX-300 Human Factors Engineering programme ensures that SSCs are positioned within the plant structure such that EIMT activities can be carried out safely and efficiently within the allocated space (006N2829, "BWRX-300 Human Factors Engineering Design Requirements Document," (Reference 8-42).

The BWRX-300 PREMS (see Section 8.5.6) is designed in accordance with the following GEH programmes and requirements specifications relating to EIMT:

- 006N4360, "BWRX-300 Reliability, Availability, Maintainability, and Inspectability Program," (Reference 8-43)
- 006N6279, "BWRX-300 In Service Inspection Requirements," (Reference 8-44)
- 006N6378, "BWRX-300 InService Testing Program," (Reference 8-45)

- 007N3083, “BWRX-300 Design for Reliability Plan,” (Reference 8-46)
- 006N4294, “BWRX-300 Design Reliability Assurance Program,” (Reference 8-47)

8.5 System and Equipment Design

8.5.1 GDA Submission Scope

It is not deemed appropriate to provide specifications of sampling and monitoring equipment or precise equipment locations at the GDA Step 2 stage, as technological development progresses at pace and BAT would not be applied at the time of procurement if the equipment to be used is specified at this early stage of design development (see Section 8.2.3.2.3). The final selection of equipment for sampling and monitoring will be subject to demonstration of BAT by a future developer/operator and capture of UK requirements for final discharge accountancy in GEH's Requirements Management process at design BL3 (**FAP.PER8-209** and **FAP.PER8-337**).

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 PER Chapter E4 (Reference 8-9). Specifications of skid-mounted or mobile equipment are excluded from the scope of the BWRX-300 UK GDA submissions at Step 2 (NEDC-34141P, "BWRX-300 UK GDA Environmental Strategy," (Reference 8-48)). .

8.5.2 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 radioactive discharges to the environment can be made. Two locations within the design have been identified:

- The final discharge point for radioactive gaseous discharge is the PVS
- The final discharge point for radioactive aqueous liquid discharges is the CWS

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

In addition to the discharge points there are other locations within the plant where in-process monitoring and sampling occur. The selection of the locations of these is expanded upon within Section 8.5.6.

8.5.2.1 Radioactive Gaseous Discharge Routes

The radioactive gaseous discharge routes for the BWRX-300 plant are described in detail in 006N7781, "BWRX-300 Heating, Ventilation, and Cooling System," (Reference 8-49) and 006N7899, "BWRX-300 Offgas System," (OGS) (Reference 8-50), and are summarised in PER Chapter E7 (Reference 8-11).

The point for radioactive 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 8-51)), noting that the TB roof is at an elevation of approximately 31.3 m (008N0988, "BWRX-300 Power Block PSAR General Arrangement," (Reference 8-52)). GEH acknowledges that this may not be the optimal stack height for representative sampling of radioactive gaseous discharges under laminar flow conditions. The need for site-specific data in order to determine the optimal PVS height has been identified in PER Chapter E6 (Reference 8-7).

FAP.PER6-203 – "*A future developer/operator shall determine the optimal PVS height and design to ensure that public exposures to gaseous discharges are ALARA. This will include:*

- *Undertaking BAT assessments to support the design and location of the gaseous discharge system main stack when site-specific data become available. This will include consideration of meteorological conditions, topography, location of surrounding buildings, location of sensitive receptors, and the final site layout*

- *Performing a stack height study using Atmospheric Dispersion Modelling Software (or equivalent) to identify the stack height above which benefits of improved dispersion from greater release height start to diminish*
- *Consideration of UK sampling and monitoring requirements for final discharge accountancy, including provision of laminar flow conditions for representative sampling, flow measurement requirements, and space/access requirements for independent sampling and monitoring by the regulator or their representative (see PER Chapter E8)"*

The PVS accepts radioactive gaseous process streams from the Heating, Ventilation and Cooling System (HVS) lines, including the Turbine Gland Seal Subsystem (TGSS) and Mechanical Vacuum Pump (MVP) exhausts, and the OGS line. Localised High Efficiency Particulate Air (HEPA) filtration is used to treat potentially contaminated areas and rooms that exhaust to the PVS (e.g., the TGSS and OGS). This serves to remove particulate from the radioactive gaseous stream that is discharged, facilitating representative sampling. It should be noted that in the current BWRX-300 Standard Design, HEPA filtration is not provided on the discharge from the MVP as this system is not anticipated to be a source of particulate (see PER Chapter E7 (Reference 8-11)).

GEH acknowledges the need for laminar flow conditions and exclusion of particulate for representative sampling of gaseous systems (see Section 8.2.1).

8.5.2.2 Radioactive Aqueous Liquid Discharge Routes

The LWM for the BWRX-300 plant is described in detail in the LWM SDD (Reference 8-38), and is summarised in PER Chapter E7 (Reference 8-11).

Should a radioactive 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, sample line, and a flow meter. It should be noted that the design of the CWS will be site-specific for each BWRX-300 project.

8.5.3 Radioactive Gaseous Discharge Sampling and Monitoring

Allowance for taking representative and accurate measurements has been considered during the BWRX-300 design process, aligned with guidance from ANSI N13.1, "Sampling And Monitoring Releases Of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities," (Reference 8-53).The final gaseous discharge point, the PVS, is discussed in Section 8.5.2. A sampling probe (final design to be determined) is positioned within the PVS. In the BWRX-300 Standard Design at the DRP for GDA Step 2, the sample is sent to a Particulate, Iodine, and Noble Gas (PING) skid from the sampling probe (PREMS SDD (Reference 8-39)). Figure 8-1 (extracted from the PREMS facility diagram (Reference 8-37)) shows the arrangement.

It is important to note that in the context of potential UK design development, the PING skid serves as an indicative example of the equipment that could be used and provides a demonstration that the BWRX-300 design has the capability for sampling and monitoring of radioactive gaseous discharges. The final selection of equipment for sampling and monitoring will be subject to demonstration of BAT by a future developer/operator (**FAP.PER8-209**) and capture of UK requirements for final discharge accountancy in GEH's Requirements Management process at design BL3 (Section 8.2.1 and **FAP.PER8-337**). Therefore, the final equipment selected for radioactive gaseous discharge accountancy for a site-specific BWRX-300 installation in the UK may not comprise a PING skid.

8.5.3.1 Design and Capabilities of PING Skids

PING skids perform the following functions:

- Radiation monitoring
- Physical extraction of samples for analysis

The PING skid installed at the PVS in the BWRX-300 Standard Design is part of the Process Radiation Monitoring Subsystem (PRM) and provides sampling and monitoring provision for final radioactive gaseous discharges. The PING skid is a combination skid installed external (but as close as practicable) to the process stream that continuously monitors the radioactivity of particulates, iodine, and noble gases (PREMS SDD (Reference 8-39)). A continuous sample is extracted from the process/discharge stream and conveyed to the assembly. After sampling, the remnants of the flow are returned to the PVS.

PING skids typically include:

- Three independent analysers (three channels – particulate, iodine, and noble gas)
- Flow extraction/control equipment
- Grab sampling taps
- Local control panel
- Audible/visual alarms

Particulate filters, iodine filters (charcoal cartridges), and grab samples are periodically collected from the skid for isotopic analysis. The PING skid also has an additional radiation detector to cover the extended range needed during accident conditions for noble gases (PREMS facility diagram (Reference 8-37)).

Further information on the PRM is provided in Section 8.5.6.2.

8.5.3.2 Sampling Probe

There are currently no details of the sampling probe design as this will be the responsibility of the future developer/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
- Provision of spare ports should be considered;
- Independent sampling provision will neeed to be included (see Section 8.7)

8.5.3.3 Tritium and Carbon-14

The BWRX-300 sampling and monitoring regime for tritium and carbon-14 in radioactive gaseous discharges is yet to be determined. It is anticipated that techniques for measuring tritium and carbon-14 by sampling and laboratory analysis will be utilised, that are aligned with UK requirements for final discharge accountancy (see Section 8.2.1). These requirements will be captured by GEH’s Requirements Management process at the BL3 design phase (**FAP.PER8-337**), providing a pathway for a future developer/operator to develop an appropriate sampling and analysis regime for tritium and carbon-14 for a site-specific BWRX-300 design in the UK.

8.5.4 Radioactive Aqueous Liquid Discharge Sampling and Monitoring

Radioactive aqueous liquid discharges from the BWRX-300 occur from the Waste Sampling Subsystem of the LWM. Details of the sampling subsystem are provided in the LWM SDD (Reference 8-38) and PER Chapter E7 (Reference 8-11), and the configuration of the subsystem is shown in Figure 8-2. Treated process water from the LWM filtration skids is collected in two Sample Tanks, which are fitted with mixing eductors and recirculation lines to enable a representative sample of the tank contents to be taken. Sampling is conducted using automated sample panels on the respective recirculation lines associated with the two sample tanks (PREMS SDD (Reference 8-39)).

Following thorough mixing and sampling, the Sample Tank contents may be routed to:

- The Condensate Storage Tank (CST) for reuse in the plant, if the processed water meets the reactor water quality specification
- The LWM Collection Tanks for reprocessing through the filtration skids, if the water chemistry is not acceptable
- The CWS for discharge to the environment, if required to maintain the overall water balance of the plant

The BWRX-300 design includes the capability to sample and monitor the final radioactive aqueous liquid discharge for final accountancy before it joins the CWS return to the environment (see Section 8.5.2). The discharge line from the Sample Tanks to the CWS is fitted with the following equipment:

- Locked closed manual valve
- Triple modular redundant set of radiation monitors (upstream of the discharge into the CWS and positioned adjacent to the line (PREMS SDD (Reference 8-39)))[6]
- Sample line (grab sampling)
- Flow control valve
- Flow meter
- Two air operated valves, which provide automatic isolation if radiation greater than a preset limit is detected in the flow stream[7]

A demineralised water line from the Water, Gas, and Chemical Pads (WGC) system is also provided for flushing the discharge line (LWM SDD (Reference 8-38)).

8.5.4.1 Tritium

Tritium is identified in Table 8-4 as a significant radionuclide in radioactive aqueous liquid discharges, in terms of the radioactivity released to the environment as a result of any such necessary discharges. The regime for tritium sampling and monitoring in radioactive aqueous liquid discharges for BWRX-300 has not yet been determined. GEH acknowledges that the UK requirement is for tritium in radioactive aqueous liquid discharges to be sampled and analysed as part of the final discharge accountancy. Capture of UK requirements (see Section 8.2.1) through use of the Requirements Management process described in PER Chapter E3 (Reference 8-1) will enable a future developer/operator to develop appropriate

[6] Radiation monitoring of the LWM is part of the PREMS (see Section 8.5.6).
[7] 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 8-39)).

sampling and analysis for tritium in radioactive aqueous liquid discharges at the BL3 (site-specific) design stage (**FAP.PER8-337)**.

8.5.5 Solid Radioactive Waste and Non-Aqueous Liquid Sampling and Monitoring

The solid radioactive wastes generated by the BWRX-300 are similar to those generated from the UK ABWR. This is discussed in PER Chapter E5 (Reference 8-10), 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 PER Chapter E5 (Reference 8-10) and GEH's SDD document 006N7733, "BWRX-300 Solid Waste Management System," (Reference 8-54)). The spent bead resins and sludges are temporarily stored in the spent resin or sludge storage tanks respectively, before onward management (SWM SDD (Reference 8-54)). The spent resin and sludge storage tanks are fitted with mixing eductors and can be recirculated to allow thorough mixing of the tank contents and collection of representative samples (SWM SDD (Reference 8-54)). 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 (PREMS SDD (Reference 8-39)):

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

The BWRX-300 is a FOAK 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 (**FAP.PER8-379**). Systems for characterisation of solid radioactive wastes are not an integral part of the Power Block for the BWRX-300 Standard Design at the DRP for GDA Step 2. The final design of these systems and interfaces, and selection of equipment to perform these functions, will be subject to optimisation by a future developer/operator.

FAP.PER8-211 - The future developer/operator shall develop detailed solid waste characterisation plans as part of management arrangements for segregation, sentencing, and processing of wastes, to enable selection of optimised disposal routes.

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 8-55)
- International Atomic Energy Agency: IAEA-TECDOC-1537, "Strategy and Methodology for Radioactive Waste Characterization," (Reference 8-56)
- Nuclear Waste Services: DEPWMP48-TR05, "Characterisation Good Practice Model," (Reference 8-57).

8.5.6 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 the PREMS SDD (Reference 8-39) and the DBR document DBR0060012, "BWRX-300 Water Chemistry Sampling and Monitoring," (Reference 8-58).

8.5.6.1 PREMS

The PREMS SDD (Reference 8-39) defines the complete set of requirements for the PREMS. The document identifies the requirements for the associated 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 PER Chapter E4 (Reference 8-9).

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 (PREMS SDD (Reference 8-39)):

- PRM: The PRM monitors various process and discharge 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 (FPs), and area radiation levels in containment
- Process Sampling Subsystem (PS): The PS collects representative process samples for analysis and provides the analytical information required for monitoring plant and equipment performance

8.5.6.2 Process Radiation Monitoring Subsystem

The PRM monitors various process and discharge 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 (PREMS SDD (Reference 8-39)). The PRM provides an assortment of monitoring equipment, with each device being tailored to the process/discharge stream according to fluid, location, and radiological hazard. In general, the following types of monitoring equipment are used (PREMS SDD (Reference 8-39)):

- 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 discharge stream and conveyed to the assembly. For example, combination skids that measure particulate, iodine, and noble gas radioactivity are commonly known as PING skids[8] (see Section 8.5.3.1)
- 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 radiation 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

[8] For the purpose of the BWRX-300 UK GDA, PING skids are an indicative example of equipment that may be used for sampling and monitoring of radioactive gaseous process streams and discharges.

- 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)
- Control Building (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 the PREMS SDD (Reference 8-39)), and Figure 8-3 gives a simplified overview of the PRM.

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

8.5.6.3 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 (PREMS SDD (Reference 8-39)).

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 (PREMS SDD (Reference 8-39)).

The proposed placement positions of the radiation monitors and the criteria for detector placement are discussed in 007N7863, “BWRX-300 Area Radiation Monitor Locations,” (Reference 8-59).

8.5.6.4 Containment Monitoring Subsystem

The CMon monitors the following containment variables:

- Containment pressure
- Containment temperature
- Containment water level
- Containment hydrogen concentration

- Containment oxygen concentration
- Containment 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 (PREMS SDD (Reference 8-39)).

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 the PREMS SDD (Reference 8-39). 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 (PREMS SDD (Reference 8-39)).

8.5.6.5 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 (PREMS SDD (Reference 8-39)).

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 (PREMS SDD (Reference 8-39)).

Table 8-7 lists processes monitored via automated sample panels, and Table 8-8 lists processes monitored via local grab sample stations (PREMS SDD (Reference 8-39)).

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 8-60).

8.5.6.6 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 (Reference 8-58)).

DBR-0060012 (Reference 8-58)) 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. Electrical Power Research Institute 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 (Reference 8-58) provides a table that details the PS measurements. This is reproduced in Table 8-9.

8.5.7 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 “BWRX-300 Power Block PSAR General Arrangement,” (Reference 8-52). 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 8-61)).

The counting room provides radioactivity measurements for isotopic analyses for all radiological effluent releases. This does not typically include the radiological environmental monitoring programme due to background radioactivity. 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 (Reference 8-61).

The design specification of the laboratory is provided in “Chemistry Laboratory Requirements,” (Reference 8-61).

It is recognised by GEH that the design specification for the laboratory is tailored to meeting U.S. requirements and therefore the future developer/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 17025:2017 (Reference 8-28) 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 PER Chapter E5 (Reference 8-10)) that will require characterisation. The future developer/operator will need to determine the specifications for the on-site laboratory, and whether it will undertake analysis of these samples or if an off-site laboratory will be used.

FAP.PER8-213 - Laboratory specifications shall be determined by the future developer/operator to comply with UK requirements, including BS EN ISO/IEC 17025:2017. Considerations include determination of the range of samples to be analysed, limits of detection required, accreditation, and if off-site laboratory support is needed.

8.6 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 Claims, Arguments, Evidence (CAE) structure are presented.

The BAT case for BWRX-300 will require development as part of the environmental permitting process under RSR, including collation of evidence to underpin claims and arguments when needed in the future. This requirement has been identified in PER Chapter E6 (Reference 8-7).

FAP.PER6.314 – *"A future developer/operator shall develop the BAT case for BWRX-300 as required to support future applications for site licences, environmental permits or planning permission. This will require:*

- *Review of the BAT methodology to be adopted*
- *Full synthesis of the evidence to underpin the arguments presented in the GDA Step 2 Demonstration of BAT submission*
- *Insertion of any additional claims and arguments into the CAE structure as the design develops"*

The methodology of how BAT will be demonstrated for the BWRX-300 is described in PER Chapter E6 (Reference 8-7). The sampling and monitoring of radioactive substances provides information to support the demonstration of BAT and confirm that systems identified as BAT are performing as expected during plant operation.

The environmental claims structure for the PER is presented in GEH's Environmental Strategy document (Reference 8-48). 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[9] relating to compliance with regulatory expectations for final discharge accountancy and the use of sampling and monitoring techniques to detect deviations from the normal operational state:

- Claim 1: Verify that radioactive discharge to the environment complies with the Permit[10]
- 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

[9] A BAT claim relating to characterisation of solid wastes is not presented, as techniques for characterisation of solid wastes will be provided by stand-alone equipment that is not integrated into the configuration of the plant design. These arrangements will be specified at later design phases beyond GDA Step 2, based on the relevant UK requirements at the time (**FAP.PER8-211**).

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

Arguments to support the three claims are provided in the following sections.

8.6.1 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.

8.6.1.1 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

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

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

The total radioactivity 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 radioactivity discharged to the environment. For this evaluation, the following parameters will be measured:

- Radioactivity 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 radioactivity concentration is multiplied to derive the total radioactivity discharged. The discharge flow rates will be measured by specific instruments.

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

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

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

8.6.1.3 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.

8.6.2 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 radioactivity 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.

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

The radioactive 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 radioactive gaseous discharge flow volumes to be recorded, allowing total radioactivity 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 8-22)). 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 8-29)), 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

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

Process water that has been treated by the LWM filtration skids is held in Sample Tanks prior to recycling to the 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 (LWM SDD (Reference 8-38)). 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 radioactivity 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.

8.6.2.3 Argument 2c: Gaseous Radioactivity 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 8-28)) 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.

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

The aqueous liquid 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 8-28) accredited) and using analytical methods that are MCERTS where it applies. The laboratory can meet the required limits of detection for the significant radionuclides.

8.6.3 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.

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

Changes to the noble gas radioactivity provide indication of deviations from the normal operating state. The major source of any increase in the noble gas radioactivity 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 radioactivity. 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 radioactivity in the PVS

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

8.6.3.2 Argument 3b: For Radioactive 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 Tanks. 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 (LWM SDD (Reference 8-38)). This prevents unsampled and uncharacterised radioactive aqueous liquid being added to the discharge
- The Sample Tank discharge line is fitted with a radiation monitor to detect elevated radioactivity. This is fitted with an automatic closure system. This ensures that the radioactivity of aqueous liquids being discharged remains below permitted limits

8.7 Independent Sampling and Monitoring

It is recognised that to meet UK requirements, independent sampling and monitoring systems will need to be provided for the final discharge points for use by the regulator or their representatives (see Section 8.2.1 and **FAP.PER8-337**).

Currently the BWRX-300 standard design does not incorporate an allowance for independent sampling and monitoring systems. This current omission is understood, and it is acknowledged that the facility and means of access for independent sampling and monitoring must be incorporated into the design for future licensing and permitting phases.

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 and monitoring system provided for use by the regulators should be designed such that it will not interrupt the operator’s own sampling and monitoring provision, 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 and monitoring.

FAP.PER8-207 - The facility and means of access for independent sampling and monitoring by the regulator or their representative shall be included in the design of the BWRX-300 for a site-specific installation in the UK, the provision of which must meet relevant UK regulatory requirements and standards. Provision of this capability shall be determined by the future developer/operator through use of BAT, with the inclusion of sufficient space to facilitate safe independent sampling and avoid interference with the operator's sampling and monitoring systems.

8.8 Conclusion

This chapter has described, at a high level, the sampling, measurement, and monitoring regime for the BWRX-300, and a pathway to future fulfilment of UK requirements for final discharge accountancy. Relevant UK requirements and Forward Actions have been identified.

GEH acknowledges the UK requirement to provide a true and accurate record of the waste that is discharged from the BWRX-300, and the consequent need to obtain representative samples of final discharges, in addition to independent sampling and monitoring provision. The design maturity of the BWRX-300 Standard Design at the DRP for GDA Step 2 is not sufficiently developed to provide detailed information on the sampling and monitoring provision, which must be tailored to local regulatory/reporting requirements for each BWRX-300 project. However, GEH is confident that the BWRX-300 design will be compatible with the taking of representative samples to meet UK final discharge accountancy requirements, through combined consideration of the factors listed below:

- The BWRX-300 Standard Design is the result of 60 years of design evolution, optimisation, learning, and investment. The design process is iterative such that modifications are based on performance data and areas for improvement identified in previous generations of BWRs
- GEH’s iterative design process includes a robust approach to Requirements Management, as described in PER Chapter E3 (Reference 8-1). This hierarchical flow of requirements and decision-making, from top-level legislative and regulatory requirements through to plant, system, and component levels, ensures that a logical design process is followed that maximises flexibility and avoids foreclosure of options
- Experience of previous GDAs and permitting programmes, combined with engagement with the UK regulators during the GDA process has facilitated identification of UK specific requirements for sampling and monitoring provision, which will be incorporated into the BWRX-300 design at the appropriate development phase (**FAP.PER8-337**). This minimises the risk of omissions or conflicts in the final site-specific design that would require significant rework of plant SSCs

Table 8-1: Key Radionuclides and Requirements for the Detection Limit in 2004/2/Euratom (Nuclear Power Reactors Radioactive Gaseous Discharges) (Reference 8-16)

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 (Radioactive Aqueous Liquid Discharges) (Reference 8-16)

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 Radioactive 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	PING skid[1] – see Section 8.5.3.1.	Kr-85	Kr-89 Other noble gases
Particulates (excluding iodines)		Co-60 Sr-90 Cs-137 Pu 239 + 240 Am-241 Total alpha[2]	Not applicable
Iodines		I-131	I-131
Tritium	See note[3]	H-3	H-3
C-14		C-14	C-14

Notes:

1. For the purpose of the BWRX-300 UK GDA, PING skids are an indicative example of equipment that may be used for sampling and monitoring of radioactive gaseous process streams and discharges.
2. Total alpha should only be reported if radionuclide-specific information on alpha-emitters is not available.
3. The BWRX-300 sampling and monitoring regime for tritium and carbon-14 in radioactive gaseous discharges is yet to be determined. It is anticipated that techniques for measuring tritium and carbon-14 by sampling and laboratory analysis will be utilised, that are aligned with UK requirements for final discharge accountancy (see Section 8.2.1 and FAP.PER8-337).

Table 8-4: Radionuclides to be Measured in BWRX-300 Radioactive 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 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 (PREMS SDD (Reference 8-39))

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
CWS Discharge	Downstream of Plant Cooling Water System (PCW) Heat Exchangers (HXs)	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)[1]
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

1. For the purpose of the BWRX-300 UK GDA, PING skids are an indicative example of equipment that may be used for sampling and monitoring of radioactive gaseous process streams and discharges.

Table 8-6: Monitoring Equipment - Containment Monitoring Subsystem (PREMS SDD (Reference 8-39))

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 (PREMS SDD (Reference 8-39))

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	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 (PREMS SDD (Reference 8-39))

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 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 (DBR-0060012 (Reference 8-58))

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.

Sampled System When in Operation	Sample[1]	Typical Process Measurements[2]
RWST	C	Conductivity, others as needed.
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).

Sampled System When in Operation	Sample[1]	Typical Process Measurements[2]
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

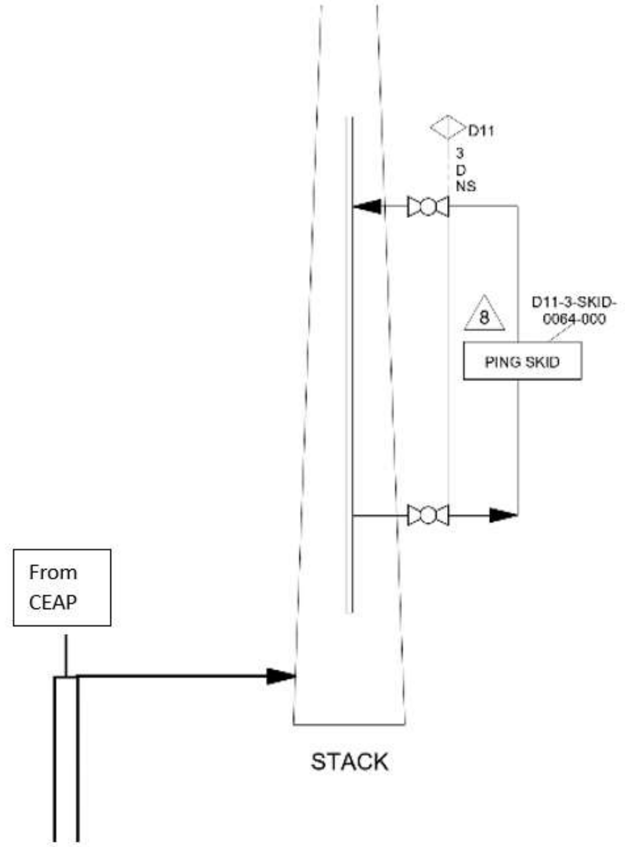

Figure 8-1: PVS Sampling and Monitoring Arrangement[11]

(Extracted from the PREMS facility diagram (Reference 8-37))

[11] For the purpose of the BWRX-300 UK GDA, PING skids are an indicative example of equipment that may be used for sampling and monitoring of radioactive gaseous process streams and discharges.

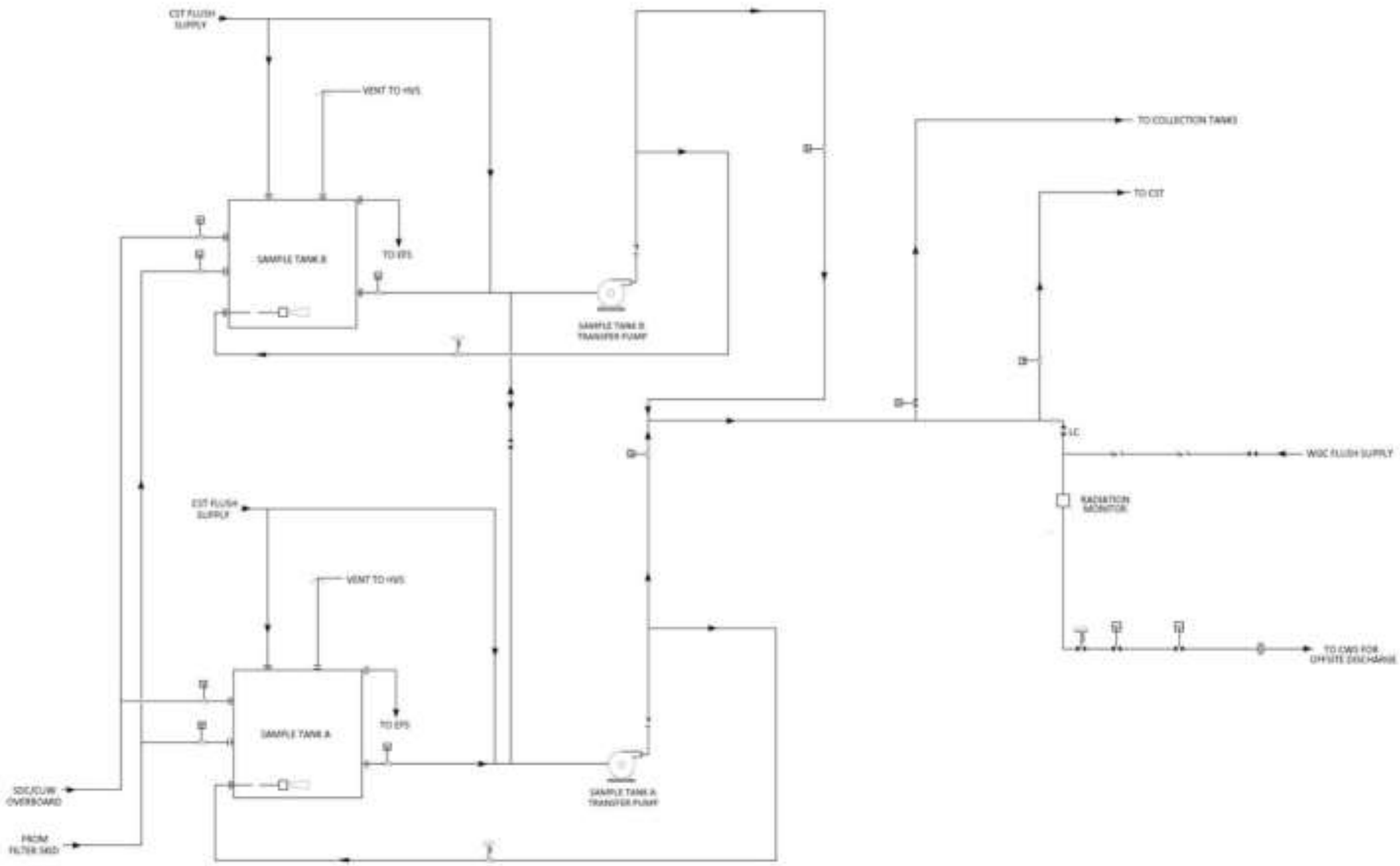

Figure 8-2: Waste Sampling Subsystem Simplified Diagram

(Extracted from the LWM SDD (Reference 8-38))

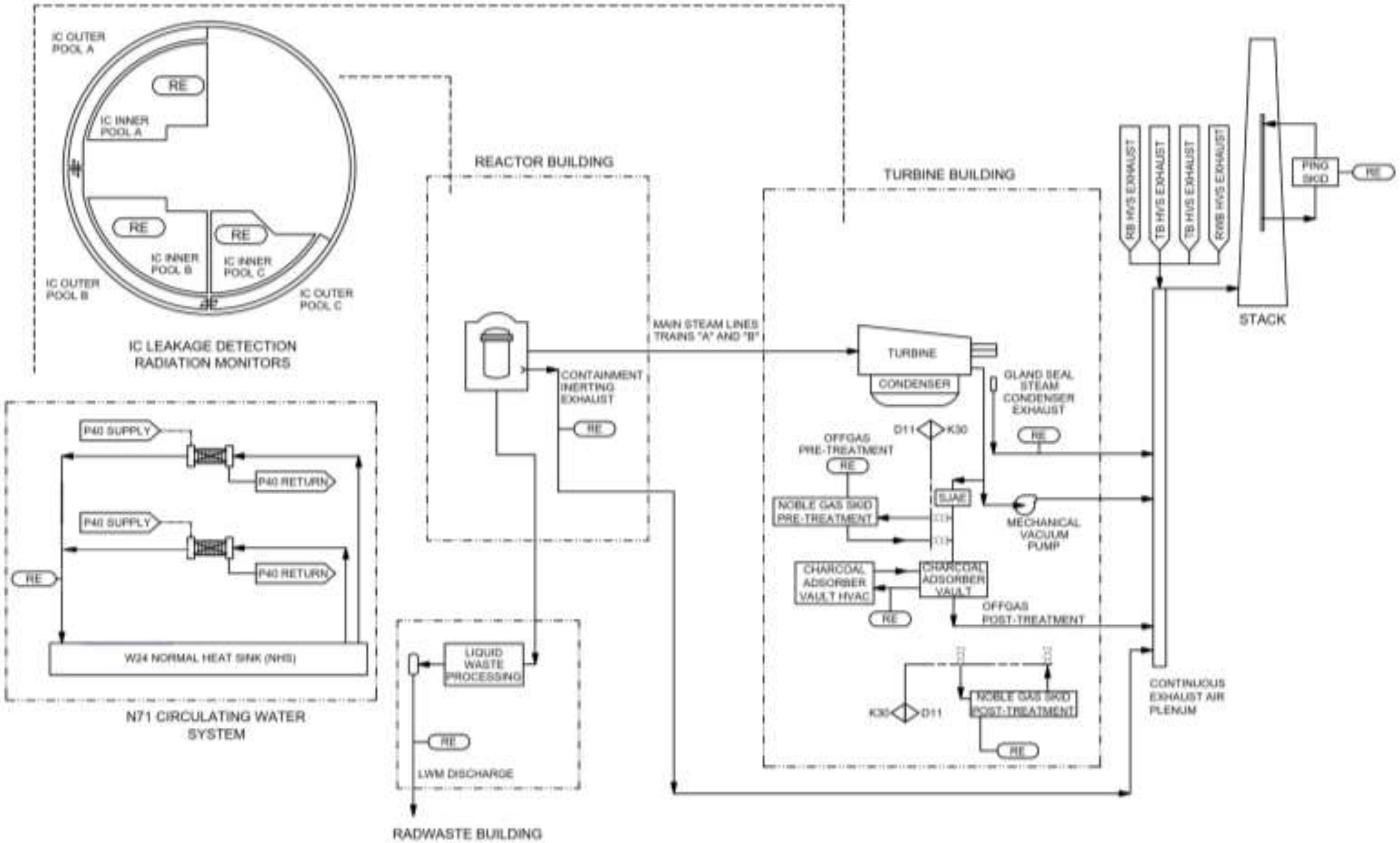

Figure 8-3: Process Radiation Monitoring Subsystem (Overview)[12]

(Extracted from the PREMS SDD (Reference 8-39))

[12] For the purpose of the BWRX-300 UK GDA, PING skids are an indicative example of equipment that may be used for sampling and monitoring of radioactive gaseous process streams and discharges.

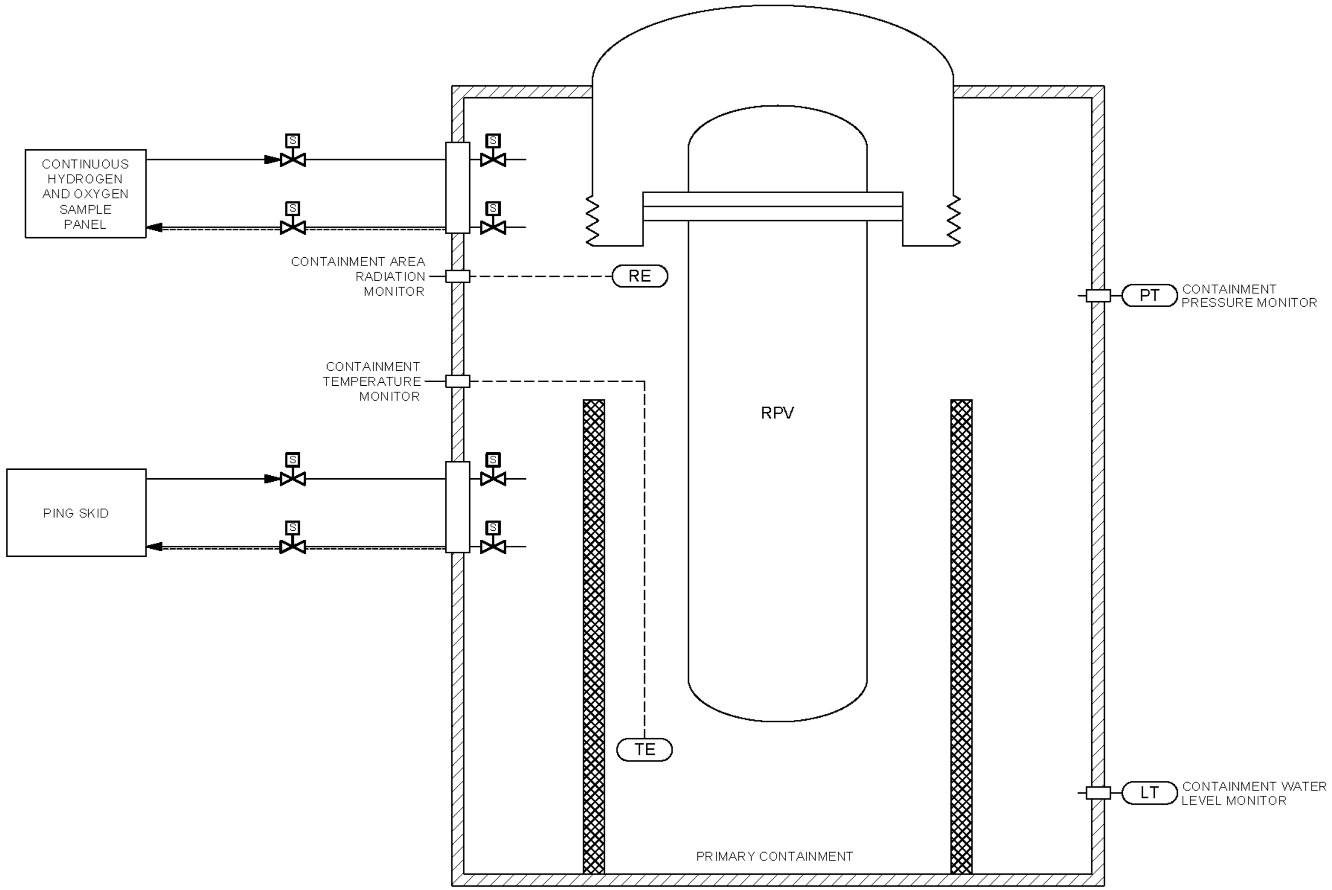

Figure 8-4: Simple Diagram of Containment Monitoring Subsystem[13]

(Extracted from the PREMS SDD (Reference 8-39))

13 For the purpose of the BWRX-300 UK GDA, PING skids are an indicative example of equipment that may be used for sampling and monitoring of radioactive gaseous process streams and discharges.

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APPENDIX A SAMPLING AND MONITORING FORWARD ACTION PLAN

Table A-1: Forward Action Plan

Unique Code	Finding	Forward Actions	Delivery Phase
PER8-207	It is a UK requirement that the environmental regulator is provided with the facility and means of access to independently undertake sampling and monitoring of the radioactive gaseous and aqueous liquid discharges from the BWRX-300. Independent sampling facilities are not included in the current BWRX-300 Standard Design, and sufficient space (as per UK guidance/standards) will be required around the discharge sampling locations to facilitate safe independent sampling in addition to the operator's sampling and monitoring systems.	The facility and means of access for independent sampling and monitoring by the regulator or their representative shall be included in the design of the BWRX-300 for a site-specific installation in the UK, the provision of which must meet relevant UK regulatory requirements and standards. Provision of this capability shall be determined by the future developer/operator through use of BAT, with the inclusion of sufficient space to facilitate safe independent sampling and avoid interference with the operator's sampling and monitoring systems.	For PCSR / Pre-Construction Environmental Report

Unique Code	Finding	Forward Actions	Delivery Phase
PER8-209	Sampling and monitoring equipment has not yet been selected other than for the functional requirements.	The future developer/operator shall select sampling and monitoring equipment and the corresponding locations at the most appropriate stage of UK site-specific design development. Selection of equipment and sampling/monitoring locations should be: - Delayed as late as possible to prevent foreclosure of options through early selection. This ensures that the most suitable equipment available at the time can be selected, and the most suitable locations identified - Considered holistically in terms of overall design development, to prevent foreclosure of options for sampling and monitoring through plant architecture and relevant system design (e.g., lack of sufficient space, lack of capability for representative sampling, etc.) Selected sampling and monitoring equipment and locations shall: - Be demonstrably BAT at the time of selection - Meet the relevant regulatory standards (e.g. Monitoring Certification Scheme (MCERTS))	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase
PER8-211	The solid waste (ILW/ Higher Activity Waste) characterisation requirements cannot be fully established at Step 2 GDA. This requires detailed information on the wastes.	The future developer/operator shall develop detailed solid waste characterisation plans as part of management arrangements for segregation, sentencing, and processing of wastes, to enable selection of optimised disposal routes.	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase

Unique Code	Finding	Forward Actions	Delivery Phase
PER8-213	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 specifications shall be determined by the future developer/operator to comply with UK requirements, including BS EN ISO/IEC 17025:2017. Considerations include determination of the range of samples to be analysed, limits of detection required, accreditation, and if off-site laboratory support is needed.	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase
PER8-214	As the site is only generic, no boundary, off-site, or GW monitoring has been designed.	When site-specific information is available, the future developer/operator shall define programmes for implementation and documentation of: • Boundary monitoring • GW monitoring • Off-site monitoring (to meet “Radioactivity in Food and the Environment” (RIFE 28), requirements).	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase
PER8-310	The current BWRX-300 Standard Design does not include a flow meter for determining the volume discharges from the PVS.	A flow meter that measures the continuous radioactive gaseous discharge flow from the PVS shall be incorporated into the BWRX-300 design for a site-specific installation in the UK. The design will be required to meet the UK regulations, standards, and guidance.	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase
PER8-337	UK-specific requirements for sampling and monitoring will need to be considered and implemented at the appropriate time during the BWRX-300 design process.	UK requirements for sampling and monitoring shall be inserted into the BWRX-300 Requirements Management process at design BL3 for UK site-specific design development.	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase

Unique Code	Finding	Forward Actions	Delivery Phase
PER8-379	Management arrangements will need to be developed for the BWRX-300 sampling and monitoring regime in order to: • Comply with final discharge accountancy and reporting requirements • Comply with environmental monitoring requirements • Inform strategy for management of radioactive wet solid wastes • Monitor plant performance to identify any deviation from the normal operating state, and determine whether equipment identified as BAT is performing as expected	A future developer/operator shall develop a detailed sampling, monitoring, and characterisation programme in order to determine final discharge accountancy and solid waste inventory, and monitor plant/system performance, including a suitable record-keeping system.	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase

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