Environment Agency


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Assessing new nuclear power station designs
Generic design assessment of General Nuclear System Limited's UK HPR1000

Consultation document

Version 1, 11 January 2021

We are the Environment Agency. We protect and improve the environment.

We help people and wildlife adapt to climate change and reduce its impacts, including flooding, drought, sea level rise and coastal erosion.

We improve the quality of our water, land and air by tackling pollution. We work with businesses to help them comply with environmental regulations. A healthy and diverse environment enhances people's lives and contributes to economic growth.

We can't do this alone. We work as part of the Defra group (Department for Environment, Food & Rural Affairs), with the rest of government, local councils, businesses, civil society groups and local communities to create a better place for people and wildlife.

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Horizon House, Deanery Road,
Bristol BS1 5AH

www.gov.uk/environment-agency

Further copies of this document are available from our publications catalogue: http://www.gov.uk/government/publications or our National Customer Contact Centre: 03708 506 506

Email: nuclear@environment-agency.gov.uk

Foreword

The Environment Agency is the environmental regulator for nuclear sites in England. Our regulation is independent of government and industry and is a key part of how we will deliver the long term goals that we set out in our five year plan, EA2025 – Our Priorities to 2025. Our goals, to help create a better place for people and wildlife, are:

- a nation resilient to climate change
- healthy air, land and water
- green growth and a sustainable future

These goals are all the more important as we begin recovery from the impact on our nation of coronavirus.

I am pleased to introduce this consultation document on the generic design assessment (GDA) that we have been carrying out on the UK Hualong Pressurised water Reactor (UK HPR1000) design. The GDA process is an important part of our regulatory approach for new nuclear power stations.

We developed the GDA process jointly with the Office of Nuclear Regulation, the UK regulator for nuclear safety and security. By working together, we are ensuring that any new nuclear power stations in this country would meet high standards of safety, security, environment protection and waste management.

The objectives of our GDA process and assessments are to:

- have early influence on proposed new nuclear power station designs to help ensure that they meet our regulatory requirements and expectations. Influence early in the design process is when it is most effective and efficient to implement changes.
- provide potential developers and investors in any new nuclear stations with our views about the designs, so reducing the associated regulatory risks.
- carry out an open and transparent process of assessment, subject to the usual national and commercial security constraints.
- ensure that regulators work together to deliver their regulation effectively and efficiently so that the best outcome overall is secured and developers are clear what is being required of them.

We began working on this GDA in 2017, at the request of government, when we began step 1 of the GDA process with General Nuclear System Ltd (GNSL) who are bringing forward the UK HPR1000 design. We published our initial assessment report in November 2018 and we are targeting completing GDA in early 2022, once we have considered all of the comments we receive in this consultation (and those from the comments process that has run throughout GDA) and we have completed our assessment.

I'd stress that this consultation is about GNSL's UK HPR1000 design and our assessment so far of its environmental acceptability. This consultation is not about energy policy. Energy policy is a matter for government and it published a white paper setting this out in December 2020, Powering our Net Zero Future, CP 337. It is good to see that government is committed to tackling climate change with urgency, including in the important area of energy.

The impacts and restrictions of coronavirus mean that we must conduct this consultation in ways that will be different to what we have done in the past. For example, we are unlikely to be able to hold face to face meetings but we will replace these so far as we can with online meetings. If circumstances change we will seek to reinstate face to face engagements but we must and will comply with government requirements and guidance.

On behalf of the Environment Agency and our assessment team I invite your comments on our assessment of the UK HPR1000. We very much look forward to hearing from you.

John Curtin

Executive Director of Local Operations,

Environment Agency.

This consultation - at a glance

Topic

This consultation is about the Environment Agency's assessment of General Nuclear System Limited's UK HPR1000 nuclear power station design. We are seeking your views on our assessment of the environmental aspects of the UK HPR1000 design.

Our consultation does not relate to a specific site. It is not about the need for nuclear power, the siting of nuclear power stations, nor the safety and security of the design.

Geographical scope

England only.

Audience

This consultation is aimed at:

- members of the public
- communities where this reactor design has been proposed
- the energy industry
- academics with an interest in nuclear power, energy production or the environment
- non-governmental organisations (NGOs)

Comments from any other interested parties are also welcome.

Duration

12 weeks. The consultation will close on Sunday 4 April 2021.

Contact details

Please complete the online response form on our Citizen Space website at https://consult.environment-agency.gov.uk. Alternatively, you can email your response to: nuclear@environment-agency.gov.uk. Or write to us (for the attention of Dr Paula Atkin) at:

Environment Agency
Ghyll Mount
Gillan Way
Penrith
CA11 9BP

If you have any queries, or would like a hard copy of this document, please email us: nuclear@environment-agency.gov.uk

Next steps

A summary of all responses will be published when the consultation is closed.

Our assessment of the UK HPR1000 continues, as does ONR's, and we have not yet reached any decisions. We will complete our assessment including carefully considering all relevant comments made during consultation and will produce a decision document that:

- sets out our decision on whether or not to issue a statement of design acceptability for the UK HPR1000
- summarises the consultation responses and issues raised
- sets out our views on those issues

We expect to:

- publish the document containing all your responses in May 2021, approximately 1 month from the close of consultation
- publish our decision document at the end of GDA, which we are targeting to complete in early 2022

Future opportunities to have your say

There will be further consultation on any environmental permit applications for the operation of this design on specific sites. You can read our publication participation document here: https://www.gov.uk/government/publications/environmental-permits-when-and-how-we-consult.

Contents

1. About this consultation document

This consultation document has 2 main purposes. Firstly, it explains the preliminary conclusions of the Environment Agency's generic design assessment (GDA) of the environmental aspects of a new nuclear power station design for the UK, General Nuclear System Ltd's (GNSL) UK Hualong Pressurised water Reactor (UK HPR1000). Secondly, it seeks your views on our assessment so far, of the environmental aspects of the UK HPR1000 design.

The Requesting Party (RP) for this GDA is constituted jointly by the China General Nuclear Power Corporation (CGN), the Électricité de France S. A. (EDF S. A.) and the General Nuclear International Limited (GNI). General Nuclear System Limited (GNSL) is appointed by the above shareholders to act on behalf of the RP.

The Office for Nuclear Regulation (ONR) is also assessing the UK HPR1000 from a safety and security viewpoint. Although we work closely with ONR, this consultation is only about the Environment Agency's assessment and not ONR's. If we receive any consultation responses that raise safety or security issues, we will pass them on to ONR.

This consultation is not about the need for nuclear power or the siting of nuclear power stations.

This document provides:

– an introduction to our role in nuclear regulation and the basis for generic design assessment (GDA) (Chapter 2)
– an outline of the UK HPR1000 design (Chapter 3)
– a guide to our detailed assessment (Chapter 4)
– our GDA preliminary conclusions, with our consultation questions, followed by our detailed assessment (Chapters 5 to 17)
– our overall preliminary conclusion (Chapter 18)
– appendices supporting the consultation document (Appendices 1 to 7)

There is also a full list of consultation questions at the end of this chapter.

You can obtain a paper copy of this document by emailing us at:

nuclear@environment-agency.gov.uk

Invitation to comment

This consultation seeks your views on our preliminary conclusions following our detailed assessment of General Nuclear System Limited's (GNSL) UK HPR1000 new nuclear power station design, and on the environmental aspects of the design. We will carefully consider your views in reaching our decision on whether to issue a statement of design acceptability.

We want to hear from all interested parties. When responding, please state whether you are responding as an individual or representing the views of an organisation.

This 12-week consultation began on Monday 11 January 2021 and will close on Sunday 4 April 2021. Please send your response to arrive by 4 April 2021.

How to respond

There are a number of ways you can let us know your views.

Online

Visit our website at https://consult.environment-agency.gov.uk. We have designed the online consultation to make it easy to submit responses to the questions. We would prefer you to comment online as this will help us to gather and summarise responses quickly and accurately. To do this, you will need to either log in or register a consultee account before providing your comments.

By email or letter

You can also submit a response by email or letter. It would help us if you would send your comments using the form provided in Appendix 7. Send them to:

Email: mailto:nuclear@environment-agency.gov.uk

By post:

For the attention of Dr Paula Atkin

Environment Agency

Ghyll Mount

Gillan Way

Penrith

CA11 9BP

Data protection privacy notice

How we will use your information

The Environment Agency will look to make all responses publicly available during and after the consultation, unless you have specifically requested that we keep your response confidential.

We will not publish names of individuals who respond.

We will also publish a summary of responses on our website in which we will publish the name of the organisation for those responses made on behalf of organisations.

In accordance with the Freedom of Information Act 2000 and the Environmental Information Regulations 2004, we may be required to publish your response to this consultation, but will not include any personal information. If you have requested your response to be kept confidential, we may still be required to provide a summary of it.

For more information see our Personal Information Charter.

Keeping up to date

We would like to keep you informed about the outcomes of the consultation. If you would like to receive an email acknowledging your response and be notified that the summary of responses and final decision document has been published please give us your email address.

By providing us with your email address you consent for us to email you about the consultation. We will keep your details until we have notified you of the responses document publication and decision document publication.

We will not share your details with any other third party without your explicit consent unless required to by law.

You can withdraw your consent to receive these emails at any time by contacting us at: nuclear@environment-agency.gov.uk with the subject "CONSULTATION: GDA of UKHPR1000".

The Environment Agency is the data controller for the personal data you provide. For further information on how we deal with your personal data please see our Personal Information Charter on gov.uk (https://www.gov.uk/government/organisations/environment-agency/about/personal-information-charter) or contact our Data Protection team at:.

Data Protection team

Environment Agency

Horizon House

Deanery Road

Bristol

BS1 5AH

Or email: dataprotection@environment-agency.gov.uk

Consultation and engagement plan

A programme of communications and stakeholder engagement is underway and will continue this during the consultation period.

You can read our joint regulators' engagement plan for this GDA at http://www.onr.org.uk/new-reactors/public-involvement.htm

You can read our consultation plan for this GDA in Appendix 3 or at https://www.gov.uk/government/publications/generic-design-assessment-of-the-uk-hpr1000-consultation-plan

Our plan includes events with stakeholders. These will be held online, by telephone or in person, unless Environment Agency guidance prevents this. They will be advertised to stakeholders at the start of the consultation.

What happens next?

We will acknowledge receipt of your response. We will consider carefully all the responses we get. If issues arise that fall outside our responsibilities, we will pass them to the appropriate government department or public body.

Your comments, where relevant to the scope of our assessment (see below), will help us decide whether or not to issue a statement of design acceptability for the UK HPR1000.

We will publish a document that:

- sets out our decision
- summarises the consultation responses and issues raised
- sets out our views on those issues

We expect to do this early in 2022.

Consultation principles

This consultation is being conducted in line with the Cabinet Office's "Consultation Principles" which can be found at: https://www.gov.uk/government/publications/consultation-principles-guidance

If you have any questions or complaints about the consultation process, please address them to our Consultation Coordinator at:

Consultation Coordinator

Environment Agency

Horizon House

Deanery Road

Bristol

BS1 5AH

Or email: consultation.enquiries@environment-agency.gov.uk

Consultation questions

Below is a full list of the questions that we are asking for responses to, as part of this consultation on the UK HPR1000 design.

Do you have any views or comments on our preliminary conclusions on:

1. Management systems?
2. Strategic considerations for radioactive waste management?
3. Best available techniques for minimising production and disposal of radioactive waste?
4. Gaseous and liquid discharges of radioactive waste?
5. Solid radioactive waste?
6. Sampling and monitoring of discharges and disposals of radioactive waste?
7. The impact of radioactive discharges?
8. Radioactive substances permitting?
9. Water use and abstraction?
10. Discharges to surface waters and groundwater?
11. Operation of installations?
12. The control of major accident hazards?
13. Fluorinated greenhouse gases and ozone-depleting substances?
14. The overall acceptability of the design?

Additionally:

Do you have any overall views or comments to make on our assessment, not covered by the previous questions?

2. Introduction

This chapter describes the Environment Agency's role in nuclear regulation and the development of new nuclear power stations, and how we carry out generic design assessment (GDA).

Regulation post exit from the EU and after the end of the transition period

In this consultation document we make reference to assessment against, and continuing compliance with, European legislation beyond the end of the transition period. This is based on our understanding at the time of writing (December 2020). Our understanding of the position is that:

We left the EU on 31st January 2020 when, under the Withdrawal Agreement, EU environmental law (existing and new) continued to have effect in UK law for the duration of the transition period (i.e. until 31st December 2020). At the end of the transition period the EU (Withdrawal) Act 2018 will ensure that existing EU environmental law continues to have effect in UK law (as 'retained EU law'). This retained EU law will be amended, where necessary, to ensure that existing levels of environmental protection are maintained. In most cases these amendments are not expected to change the effect of the law but in some cases they may. Any relevant changes that take effect after the time of writing this document will be taken into account in our final decision whether or not to issue a SODA for the HPR1000.

More information on the government's approach and position is available on the .gov.uk website at https://www.gov.uk/guidance/upholding-environmental-standards-from-1-january-2021

This page at the time of writing advises that:

"Some environmental legislation will stay the same and some will be adapted so that environmental standards will be maintained from 1 January 2021.

What will stay the same:

The UK government is committed to maintaining environmental standards and international obligations from 1 January 2021. The UK will continue its aim set out in the 25 Year Environment Plan to be the first generation to leave the natural environment in a better state than it inherited it.

Existing EU environmental laws will continue to operate in UK law. The following will also continue:

- *the UK's legal framework for enforcing domestic environmental legislation by UK regulatory bodies or court systems*
- *environmental targets currently covered by EU legislation - they are already covered in UK legislation*
- *permits and licences issued by UK regulatory bodies*

What will be changed or introduced:

From 1 January 2021, current legislation will be changed to:

- *remove references to EU legislation*
- *transfer powers from EU institutions to UK institutions*

- *make sure the UK meets international agreement obligations*

The UK government has introduced a new Environment Bill. It will establish a new, independent statutory body - The Office for Environmental Protection (OEP). The OEP will oversee compliance with environmental law and will be able to bring legal proceedings against government and public authorities if necessary. The OEP will also scrutinise and advise government. Environmental principles will guide future government policy.

The UK government will introduce interim measures before the OEP is set up. These interim arrangements will continue until the OEP becomes fully operational."

Government policy on nuclear new build - the origins of GDA

Government is responsible for the UK's energy policy and it set out its current position in the December 2020 white paper, "Powering our Net Zero Future". In the white paper government highlights the need to address climate change urgently and it sets out the strategy for wider energy systems so as to achieve the UK's target of net zero greenhouse gas emissions by 2050. The strategy includes a continuing and future role for nuclear generation to provide reliable clean electricity and it sees a potential additional role for advanced modular reactors (AMR) to provide high temperature process heat in the future. Government's position is that additional new nuclear power stations are required and it intends to bring at least one further large scale nuclear power station to a final investment decision by the end of the current parliament. It is also proposing to invest in the development of a UK designed small modular reactor (SMR) and open up generic design assessment to SMR technologies. It also commits to research and development funding for AMR and to continue to develop fusion. The nuclear regulators, the Environment Agency and the Office for Nuclear Regulation developed previously the generic design assessment process at the request of government to enable early assessment of safety, security and environment protection aspects of new reactor designs at a generic level, before receiving an application to consider a particular nuclear power station design at a specific location. Access to generic design assessment is controlled by government as the selection of which reactor designs should be assessed is primarily a UK strategic or commercial consideration or both.

Our role in nuclear regulation

The Environment Agency regulates the environment protection aspects of nuclear sites in England such as nuclear power stations, nuclear fuel production plants, and plants for reprocessing spent nuclear fuel. We do this through a range of environmental permits. These permits may be needed for one or more of the site preparation, construction, operation and decommissioning phases within the plant's life cycle.

The permits we issue can include conditions and limits. In setting these we take into account all relevant national and international standards, and UK legal and policy requirements, to ensure that people and the environment will be properly protected. These standards and requirements are described in government and Environment Agency guidance available at:

www.gov.uk/government/collections/radioactive-substances-regulation-for-nuclear-sites

www.gov.uk/government/policies/managing-the-use-and-disposal-of-radioactive-and-nuclear-substances-and-waste

We inspect existing nuclear sites to check that the operator is complying with the conditions and limits, and that it has arrangements in place to help ensure compliance. We may take enforcement action, for example, issuing an enforcement notice or taking a prosecution if it is not.

We regularly review permits, and vary (change) them if necessary, to ensure that the conditions and limits remain effective and appropriate and that people and the environment continue to be properly protected.

We work closely with ONR, which regulates the safety and security aspects of nuclear sites.

Our regulatory role in the development of new nuclear power stations

As for existing nuclear sites, any new nuclear power station will require environmental permits from us to cover various aspects of site preparation, construction, operation and eventually decommissioning. In the light of government and industry expectation that power stations of almost the same design might be built on a number of sites and potentially be run by different operating companies, we have split our process for assessing and permitting the operational stage of new nuclear power stations into 2 phases.

First phase: Generic design assessment

In the first phase, generic design assessment, we carry out assessments of candidate designs. We provide an assessment which sets out our findings about the acceptability of the design. There may be GDA Issues and Assessment Findings associated with our assessment. For the UK HPR1000, we are in this phase now, and this consultation document is about our assessment of the UK HPR1000 design.

- A **GDA Issue** is an unresolved issue considered by regulators (ourselves or ONR) to be significant, but resolvable, and which needs resolving before nuclear island safety-related construction of the reactor could be considered.
- An **Assessment Finding** is an unresolved issue of lesser significance, not considered critical to the decision to start nuclear island safety-related construction. In many cases resolving the issue will rely on one or more of the following:
    - site-specific information
    - operator design choices
    - operator-specific features, aspects or choices
    - operator choices on organisational matters
    - the plant being at some stage of construction or commissioning
    - the level of detail of the design being beyond what can reasonably be expected in GDA (for example, manufacturer or supplier input is required, or areas where the technology changes quickly such that early choices could lead to the design becoming obsolete)

An Assessment Finding will need to be addressed, as part of our normal regulatory process, by a future operator during the detailed design, procurement, construction or commissioning phase of the new build project. We may include Assessment Findings in site-specific permits, if issued, by means of pre-operational conditions or requirements.

During GDA, we work closely with ONR to assess areas where we have complementary regulatory responsibility, including radioactive waste and spent fuel management, and management arrangements for controlling design changes and GDA submission documents. We have established a Joint Programme Office (JPO), which administers the GDA process on behalf of the regulators.

Second phase: Site-specific

In the second phase, we receive applications for environmental permits for specific sites. In determining these applications, we take full account of the work we have done during GDA, so that our efforts are focused on operator and site-specific matters, including how the operator has addressed any outstanding GDA Issues (where there is overlap between a site-specific application and completion of GDA) or Assessment Findings. We also carry out further public consultation before deciding whether or not to issue operational permits for a specific site.

Our input to the government's actions to facilitate nuclear new build

In addition to our regulatory role, we have provided specialist advice, where appropriate, and responded to consultations relating to the actions taken by government to:

- reduce the regulatory and planning risks associated with investing in new nuclear power stations
- ensure operators of new nuclear power stations set aside funds to cover the costs of decommissioning and long-term waste management and disposal

These include:

- Strategic siting assessment - this work identified those sites that are strategically suitable for the deployment of new nuclear power stations by the end of 2025. The selected sites are listed in the 'National policy statement for nuclear power generation: EN-6' ('NPS EN-6') (GB Parliament, 2011). This provides the framework for decisions on planning consent (Development Control Orders). Such decisions are taken by the Secretary of State at the Department for Business, Energy and Industrial Strategy (BEIS) on the basis of recommendations made by the Planning Inspectorate.
- Justification - before any new type of nuclear power station can be built in the UK, it must be 'justified', that is, it must be shown that the net benefits outweigh any detriments to health. The Department for Environment, Food and Rural Affairs (Defra) will be acting as the Justifying Authority and they, will begin considering Regulatory Justification for the UK HPR1000 in 2021.
- Funded decommissioning programme - 'The Energy Act 2008' (GB Parliament, 2008) requires any operator of a new nuclear power station to have a funded decommissioning programme, approved by the Secretary of State, in place before construction begins and to comply with this programme. The government published funded decommissioning programme guidance in December 2011 (DECC, 2011).

About generic design assessment

GDA means that we assess the acceptability of the environmental aspects of an overall reactor design before individual site applications are made. GDA allows us to get involved with designers and potential operators of new nuclear power stations at the earliest stage, where we can have most influence and where lessons can be learned before construction begins. This early involvement also means that designers and potential operators can better understand the regulatory requirements before they make significant investment decisions.

GDA process

The GDA for the UK HPR1000 has been carried out under GDA guidance published in 2016, the Process and Information Document (P&ID). We published new guidance, GDA guidance for requesting parties, in 2019 which will apply to any new request for a GDA. The updated guidance was published to allow a future Requesting Party (RP) to complete the GDA process in stages or to complete a partial GDA. The scope and requirements for a full GDA in the new process remain the same as in the original P&ID.

Our P&ID sets out in detail the information that we require and the process that we follow during GDA of the UK HPR1000. Our process as outlined in the P&ID has 6 main elements, with a seventh element to be used when we issue an interim statement of design acceptability (iSoDA).

1. **Initiation (GDA Step 1) -** A **request** comes from government to the Environment Agency asking us to carry out a GDA on a specific design**.** We establish a **Section 37 agreement** (Environment Act 1995) with the RP. We work with the RP and ONR to agree a programme and project management arrangements for the GDA submission.
2. **Initial assessment (GDA Step 2)** - We carry out a high-level assessment of the submission made by the RP, specifically looking for significant issues with the design or any matters that are obviously unacceptable. We also identify any necessary information missing from the submission. We will also look in more detail at:
    - the RP's management arrangements for carrying out the GDA
    - the definition of the generic site, to ensure appropriate reflection of potential UK sites
    - the potential impact of the proposed discharges, to give early assurance that UK limits and constraints will be complied with
3. **Detailed assessment (GDA Step 3) -** we carry out a detailed assessment of the submission, examining claims and arguments made and the evidence that supports them. We will come to a preliminary view on whether:
    - we might issue a statement of design acceptability (SoDA)
    - we might issue an interim statement of design acceptability (iSoDA) with associated GDA Issues
    - the design is unsuitable and we will not issue a statement
4. **Consultation** - we consult widely on our preliminary view following detailed assessment. We provide a consultation document explaining the reasons for our preliminary view. We also publish our more detailed technical assessment reports to help inform the consultation.
5. **Post consultation review** - we carefully consider all relevant responses to the consultation and update our assessments where necessary. Where responses lie outside our responsibilities, we pass them to the appropriate regulator, government body or public body for consideration.
6. **Make a decision** - we decide whether to issue a SoDA or iSoDA or neither. We publish a decision document explaining the reasons for our decision and our updated technical assessment reports.
7. **Resolving GDA Issues -** we assess the further information provided by the RP to clear the GDA Issues associated with an iSoDA and, if satisfied, issue a full SoDA. For both initial and detailed assessment, we use a tiered approach for raising concerns or requesting further information that depends on the level of our concern.
    - **Regulatory Query (RQ)** - this is a request for clarification or further information and does not necessarily indicate any perceived shortfall in the design.
    - **Regulatory Observation (RO**) - we raise an RO when we identify a potential shortfall that requires action and new work to address it. Each RO can have several associated actions.
    - **Regulatory Issue (RI) -** we raise an RI when we identify a serious shortfall that could potentially prevent us issuing a SoDA, and that requires further work. Each RI can have several associated actions.

Both ROs and RIs are published on the [Joint Regulators' website](). It is possible for an RQ to escalate to an RO or RI, and for an RO to escalate to an RI.

Scope of GDA

While the regulators require a certain minimum level of detail to complete a GDA, we recognise that full engineering details of the design may not be available at the GDA stage, as it is normal to finalise some of these as part of the procurement and construction programme.

The scope of what is included within GDA depends on the information supplied by the Requesting Party (GDA is a voluntary process). However, the information provided for GDA needs to be sufficient in scope and detail to enable a meaningful assessment of the safety, security and environmental aspects of the design. We will not proceed with an assessment if essential information is left out.

The scope of GDA is defined by the total amount of information provided in the submission to the regulators (as recorded in a 'master document submission list'), together with the 'design reference'. The design reference is a list of all the documents that together describe the design of the reactor and associated plant. We expect this to be 'frozen' at a specific date known as the 'design reference point'.

GDA outcomes

There are a number of possible outcomes for a GDA:

1. If we are fully content with the environmental aspects of the design, we provide the Requesting Party with a statement of design acceptability (SoDA). However, there may still be some Assessment Findings that the Requesting Party or a future operator will need to resolve at a later stage, for example, during procurement or commissioning. An Assessment Finding is an unresolved issue that is not considered critical to the decision to start nuclear island safety-related construction - it will need to be addressed during the design, procurement, construction or commissioning phase of the new build project. A decision to issue a SoDA can only be reached when we have carried out a full public consultation.
2. If we are largely content with the environmental aspects of the design, we provide the Requesting Party with an interim statement of design acceptability (iSoDA) that specifies the outstanding GDA Issues. We will only do this if the Requesting Party is able to provide a credible resolution plan that identifies how it will address each of the GDA Issues. A full SoDA may replace an iSoDA once we are content that all the GDA Issues have been resolved. A GDA Issue is an unresolved issue that is significant, but resolvable, and which needs resolving before nuclear island safety-related construction of the reactor could be considered. A decision to issue an iSoDA and then a SoDA can only be reached when we have carried out a full public consultation.
3. If we are not content with the environmental aspects of the design, we do not provide a SoDA or iSODA to the Requesting Party.

Regulatory basis for GDA

We provide a SoDA as advice to the Requesting Party, in accordance with Section 37 of the Environment Act 1995 (GB Parliament, 1995). It has no other formal legal status. However, we will take full account of the work that we have done during GDA if we receive applications for environmental permits relating to a design that has been through GDA.

A SoDA will, subject to the scope of the GDA and the nature of the design, state our view on the acceptability of the design to be permitted for:

- the disposal of radioactive waste (gaseous, aqueous, non-aqueous and solid), under the Environmental Permitting Regulations 2016 (EPR16) (GB Parliament, 2016)

- the discharge of aqueous effluents containing non-radioactive substances to surface waters and groundwater, under EPR16
- the operation of certain conventional plant (for example, standby generators, combustion plant used as auxiliary boilers), under EPR16
- the disposal or recovery of non-radioactive waste, under EPR16
- the abstraction of water from inland waters or groundwater, under the Water Resources Act 1991 (WRA91) (GB Parliament, 1991)

It will also state our view on the acceptability of the design with respect to the environmental requirements of the Control of Major Accident Hazards Regulations 2015 (COMAH15) (GB Parliament, 2015a).

Our GDA process focuses mainly on matters relevant to the disposal of radioactive waste.

This is because:

- the generation of radioactive waste is intrinsically linked to the detailed design of a nuclear reactor and its associated plant
- permitting the disposal and discharge of radioactive waste has, in the past, been the area of regulation with the longest lead time for our permitting of new nuclear power stations

We also address, as far as is practicable at a generic level, aspects of the design related to the other regulatory requirements listed above.

Completion of a GDA does not mean that an operator can build the nuclear station. All proposals still need to obtain all relevant site permissions from the regulators.

New nuclear power stations are likely to need new or enhanced flood defence structures that will require a flood risk activity permit under the Environmental Permitting Regulations 2016. As flood defence is necessarily site-specific, we do not consider this matter during GDA. However, flooding is considered at GDA, by the Office for Nuclear Regulation, as part of their assessment of external hazards.

GDA for the UK HPR1000

Initial assessment

Our process and the outcome of our initial assessment of the GDA for the UK HPR1000 is described in our initial assessment statements of findings. This is summarised below.

In our initial assessment, we examined the management systems used for producing the submission and the impact of the proposed radioactive discharges. We formed a view as to whether the submission contained any matters that are obviously unacceptable or whether we could identify any significant design modifications that are likely to be needed. We also assessed whether there was enough information for us to carry out the detailed assessment stage.

At the initial assessment stage and based only on information we had seen up to 30 June 2018, our conclusions were:

- we did not find any matters within the submission that were obviously unacceptable
- we did not identify any significant design modifications that are likely to be needed before we could issue a permit
- GNSL has an adequate management system in place to control the content and accuracy of the information it provides for GDA for the current stage

- as calculated by GNSL, the annual radiation impact of the UK HPR1000 design on people would be below the UK constraint for any single new source
- based on the information we were given it is unlikely that radioactive discharges would exceed those of comparable power stations, but GNSL needs to demonstrate this for discharges and for quantities of solid waste
- the submission did not contain the level of information that we need in order to carry out a detailed assessment

GNSL committed to provide all the required information within a timescale that, subject to the quality of the information, should allow us to carry out our detailed assessment and to maintain our overall target of completing a meaningful GDA within 4 years.

These conclusions were based on our initial assessment of the information we received up to 30 June 2018 and considered any public comments received up to 31 August 2018. The initial assessment statement of findings was published on the 15 November 2018.

Detailed assessment

We began our detailed assessment in November 2018. Where practicable at the generic level, our assessment has taken account of all relevant national and international standards, and UK legal and policy requirements, to ensure that people and the environment will be properly protected. These standards and requirements are described in government and Environment Agency guidance available at: https://www.gov.uk/government/collections/radioactive-substances-regulation-for-nuclear-sites

and

https://www.gov.uk/government/policies/managing-the-use-and-disposal-of-radioactive-and-nuclear-substances-and-waste.

The submission

We carried out our assessment using the information GNSL provided in the 'Pre-Construction Environmental Report' (PCER) and 'Pre-Construction Safety Report' (PCSR). These documents and their supporting references are collectively referred to as 'the submission'. The documents are publicly available on the GNSL website:

- PCER and PCSR version 000, issued November 2018
- PCER and PCSR version 001, issued February 2019
- PCER version 001-1 and PCSR version1 amendment document, issued January 2021.

The latest documents were updated to reflect modifications and additional information arising during the ongoing GDA assessment to ensure the most recent information was available to support this consultation.

Scope of the UK HPR1000 GDA

While the regulators require a minimum level of detail to complete a GDA, we recognise that full details of the design may not be available at the GDA stage. It is normal to finalise some of these as part of the procurement and construction programme.

The scope of what is included within GDA depends on the information supplied by the Requesting Party (GDA is a voluntary process). However, the information provided for GDA needs to be sufficient in scope and detail to enable a meaningful assessment of the safety, security and environmental aspects of the design. We will not proceed with an assessment if essential information is left out.

The scope of the UK HPR1000 GDA is defined by the Requesting Party (GNSL) and includes a single reactor unit situated in a generic site, based on site parameters applicable to the UK.

The scope for the UK HPR1000 GDA includes:

- buildings that are subject to safety classification (Class 1 & 2) or are important to nuclear safety, environmental protection or security
- all systems that perform or support the following functions:
    - reactivity control
    - containment of radioactive substances
    - heat transfer or removal
    - environmental protection
    - security

Liaison with ONR and other bodies

We have worked closely with ONR throughout GDA. This enables us to achieve a balance between environmental and safety issues in relation to radioactive waste. We have considered its relevant Step 1, Step 2 and Step 3 reports (http://www.onr.org.uk/new-reactors/uk-hpr1000/reports.htm).

Comments process

There is a separate comments process, which provides the opportunity for people to access information about the UK HPR1000, submit comments and receive responses from the Requesting Party. This has remained available throughout the detailed assessment stage.

GNSL's website (http://www.ukhpr1000.co.uk/) contains regularly updated design information, together with information provided to the regulators, except that which is commercially confidential or subject to national security restrictions.

Where they relate to our areas of interest, our detailed assessment has taken account of comments received up to 30 June 2020, and GNSL's responses to those comments. We will address any later comments on environmental issues alongside responses to this consultation in our decision document.

Assessment reports

We have documented our detailed assessment in a series of Assessment Reports. These are listed in Appendix 5 and summarised in Chapters 5 to 17 of this document.

Draft iSoDA

To help the consultation process, we have included in this document (Appendix 1) a draft iSoDA for the UK HPR1000, based on our preliminary view (before consultation).

Should all the identified potential GDA Issues be resolved before the end of GDA and no new issues arise, we may revise our preliminary decision to be able to issue a full SoDA (subject to consideration of the consultation responses).

Consultation

We are now in the consultation stage of our process, which runs from 11 January 2021 to 04 April 2021. We are consulting widely so that interested parties can bring any issues to our attention. We have not yet made any final decisions and will not do so until we have carefully considered all the responses to the consultation.

Post consultation review

We will acknowledge all responses, but we will not generally enter into further correspondence with those who respond.

We will carefully consider each response that we receive. If matters arise that fall outside our responsibilities, we will pass them to the appropriate regulator, government department or public body.

We may seek advice from other organisations, such as government departments and public bodies that have expertise in specific topics, for example, the Centre for Radiation, Chemical and Environmental Hazards (part of Public Health England), which is the government's adviser on radiological protection. If necessary, we may also seek further information or clarification from GNSL.

Decision

In the light of all the information obtained, including that which we receive during and after consultation, we will decide whether to issue a SoDA and, if so, whether any GDA Issues should be attached to it (iSoDA).

We will publish a document that:

– sets out the basis for our decision
– summarises the consultation responses and issues raised
– sets out our views on those issues that fall within our responsibilities and how they have informed our decision making. For responses relating to issues falling outside our responsibilities, we will identify which government department or public body we pass them to

Working with the public and interested groups

We have continued to raise awareness of GDA and the opportunity for the public to comment by:

– publishing information on GOV.UK and our joint regulators website
– publishing information such as leaflets or infographics
– sharing information through e-bulletins and social media accounts
– sharing information through community channels and local advocates
– working with journalists to share information in local and national media
– meeting with and listening to NGO concerns at nuclear liaison fora
– meeting with groups representing communities and interests near the proposed development at Bradwell
– briefing MPs, local councils and parish councils
– publicising our work at national and local events
– participating in conferences, meetings and exhibitions run by others
– providing information to nuclear and energy academics and trade unions
– asking GNSL to promote the public comments process through its website, social media accounts and communications materials

You can read our full consultation plan for this GDA in Appendix 3 or at https://www.gov.uk/government/publications/generic-design-assessment-of-the-uk-hpr1000-consultation-plan/environment-agencys-consultation-plan-on-the-generic-design-assessment-of-the-uk-hpr1000

3. The UK HPR1000 design

This section provides a brief outline of the design and how wastes are proposed to be created, processed and disposed of in the UK HPR1000 reactor design.

Outline of design

The UK HPR1000 design for GDA is a pressurised water reactor (PWR) capable of generating 1,180 megawatts (MW) of electricity. Further detail on the design can be found in chapter 2 of the Pre-construction Safety Report (PCSR), which can be found on the UK HPR1000 website. A summary is provided below.

In the reactor core, the uranium oxide fuel is cooled by water, which also acts as the neutron moderator necessary for a sustained nuclear fission reaction. The heat from the primary coolant is used to produce steam in a secondary circuit, via a steam generator. Steam from the secondary circuit drives a turbine-generator to produce electricity. The primary coolant remains within the reactor (Figure 3-1).

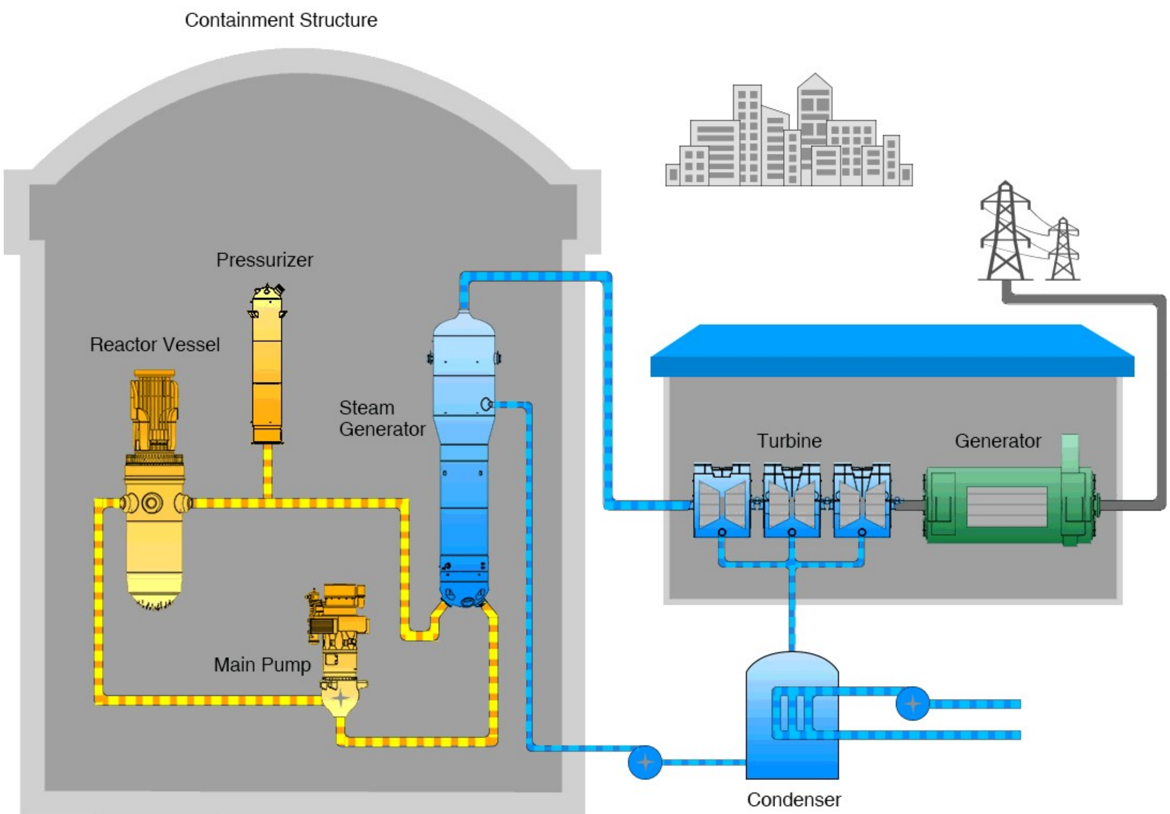

Figure 3-1 A simplified diagram of the internal workings of the UK HPR1000

Image copyright of China General Nuclear

The main ancillary facilities include a spent-fuel storage pond, spent-fuel interim storage facility, water treatment systems for maintaining the chemistry of the water circuit, diesel generators for providing power in the event of loss of grid supplies, and waste treatment and storage facilities. Turbine condenser cooling water may be provided by a once-through system or by cooling towers.

There are no units of the CGN designed HPR1000 operating yet, but there are 4 units under construction in China (Fangchenggang units 3 and 4 and Tiapingling units 1 and 2). Fangchenggang unit 3 is the reference design for the UK HPR1000.

The HPR1000 design is an evolution of previous power station designs, including the M310 design (4 units in operation, the CPR1000 (16 units in operation) and the ACPR1000, with 2 units in operation (Yangjiang units 5 and 6) and 2 units currently under construction (Hongyanhe units 5 and 6).

Sources, processing and disposal of radioactive waste

Radioactive waste will arise from activities associated either directly or indirectly with operating and maintaining the reactor, and ultimately, from decommissioning the plant. In particular, operating a PWR generates radioactive waste in the water of the primary coolant circuit.

Liquid radioactive discharges arise mainly from effluent associated with systems for collecting and treating the primary coolant water. Other sources of such effluent include the spent-fuel storage pond, washings from plant decontamination, drainage from change-rooms, let-down of secondary circuit coolant, and effluent from the active laundry (if present on site). Effluent treatment facilities include storage, hold up tanks, filters, demineraliser ion exchange resin beds and evaporators. Facilities to monitor effluents before they are released are provided.

The main source of gaseous radioactive emissions is from within the primary coolant circuit which, at outage, is degassed to the gaseous waste treatment system (GWTS) which is a carbon bed delay system. This system slows down the radioactive gases allowing much of the short-lived radionuclides to decay before they are released to atmosphere. Gaseous radioactivity will also be present in the main process buildings, which are serviced by the heating, ventilation and air-conditioning (HVAC) systems. Discharges from these systems are via a main stack, which is expected to be located on the top of the fuel building. There is provision for monitoring these discharges, after they have been filtered through high efficiency particulate air (HEPA) filters.

Other radioactive waste includes spent ion exchange resins, spent filter media, worn out plant components and parts replaced during plant maintenance, contaminated protective clothing and tools, rags and tissues, and waste oil. Facilities for managing these types of waste include resin storage tanks, space for providing waste treatment and packaging facilities, and storage areas for packaged low-level and intermediate-level waste. All radioactive plant components are likely to become waste when the plant is decommissioned. Similar waste currently produced in the UK is disposed of via the national Low Level Waste Repository (LLWR) in Cumbria or stored, pending disposal, at a future deep geological disposal facility (GDF).

Spent fuel will be stored under water in the spent-fuel storage pond for a period of time. It is then transferred to an interim spent fuel store until a GDF is available. The design includes space for a spent fuel interim storage facility.

Non-radioactive waste

Non-radioactive waste is produced from operating and maintaining the plant. It includes:

– combustion gases discharged to the air from the diesel generators (emergency back-up power supply)
– secondary circuit discharges, containing water-treatment chemicals from the turbine-condenser cooling system and other non-active cooling systems, which is discharged to rivers or the sea

- oils
- redundant plant and components replaced during plant maintenance
- general waste, such as waste from offices and canteens

Non-radioactive substances will also be present in the radioactive waste and may affect its impact on the environment and how it is managed and disposed of. For example, liquid radioactive discharges will contain boron compounds. Boron (a neutron absorber) is added to the primary coolant circuit to help control reactivity in the core.

Waste, surface water and other discharges, and the need for dewatering abstraction, would also arise during construction, as for any major construction project, and also in operation and decommissioning. These are out of the scope of GDA, as they are best considered if, or when, site-specific proposals are made.

4. Guide to our detailed assessment

This chapter explains where you can find the discussion of specific topics in the rest of this document, and gives some general information about our detailed assessment.

Detailed assessment topics

In the following chapters, we set out a summary of our detailed assessment, preliminary conclusions and our consultation questions for:

- management systems (Chapter 5)
- radioactive substances regulation topics
    - strategic considerations for radioactive waste management (Chapter 6)
    - best available techniques for minimising production and disposal of radioactive waste (Chapter 7)
    - gaseous and liquid discharges of radioactive waste (Chapter 8)
    - solid radioactive waste (Chapter 9)
    - monitoring discharges and disposals of radioactive waste (Chapter 10)
    - impact of radioactive discharges on public and wildlife (Chapter 11)
    - other environmental regulation topics
        - water use and abstraction (Chapter 13)
        - discharges to surface waters and groundwater (Chapter 14)
        - operation of installations (Chapter 15)
        - control of major accident hazards (Chapter 16)
        - fluorinated greenhouse gases and ozone-depleting substances (Chapter 17)

Our preliminary conclusion on the acceptability of the design for radioactive substances permitting is set out in Chapter 12 and that on the overall acceptability of the design in Chapter 18.

A full description of our detailed assessment can be found in our separate Assessment Reports:

- Preliminary detailed assessment of management systems for General Nuclear System Limited's UK HPR1000 design - AR01 (Environment Agency, 2021a)
- Preliminary detailed assessment of strategic considerations for radioactive waste management for General Nuclear System Limited's UK HPR1000 design - AR02 (Environment Agency, 2021b)
- Preliminary detailed assessment of BAT for General Nuclear System Limited's UK HPR1000 design - AR03 (Environment Agency, 2021c)
- Preliminary detailed assessment of gaseous and liquid discharges of radioactive waste for General Nuclear System Limited's UK HPR1000 design - AR04 (Environment Agency, 2021d)
- Preliminary detailed assessment of solid radioactive waste and spent fuel for General Nuclear System Limited's UK HPR1000 design - AR05 (Environment Agency, 2021e)
- Preliminary detailed assessment of sampling and monitoring for General Nuclear System Limited's UK HPR1000 design - AR06 (Environment Agency, 2021f)

- Preliminary detailed assessment of generic site description and assessment of dose to the public and to wildlife for General Nuclear System Limited's UK HPR1000 design - AR07 (Environment Agency, 2021g)
- Preliminary detailed assessment of other environmental regulations for General Nuclear System Limited's UK HPR1000 design - AR08 (Environment Agency, 2021h)

The chapters in this consultation document are slightly different to those we presented for previous GDAs. It is important to note that the level of assessment remains the same, the topic areas have simply been placed under different chapter headings so that they align better with our detailed assessment reports and to minimise repetition of information.

About our detailed assessment

Our conclusions, all of which should be considered preliminary pending the outcome of this consultation, identify any matters that would be GDA Issues attached to an iSoDA, if we decide to issue one.

At the time of writing, potential GDA Issues are due to the following:

- identified shortfalls across UK HPR1000 safety case documentation in the use of operating experience (OPEX), including insufficient evidence of a systematic approach being used, narrow selection of OPEX, and insufficient justification on the applicability and the links between topic area OPEX
- a misalignment in timing of the demonstration of 'best available techniques' (BAT) and 'as low as reasonably practicable' (ALARP), resulting in a possibility that the design is not yet optimised
- further information required in the optioneering study and justification for the choice of HEPA filter type and the demonstration of the minimisation of the radioactivity of gaseous radioactive waste discharges by the optimisation of the HVAC system is BAT
- a requirement for further information in relation to the long-term storage requirements for the selected fuel and a demonstration that the conceptual design for the spent fuel interim store (SFIS) will meet these requirements
- the requirement for better evidence for the strategy for the management of in-core instrument assemblies (ICIAs) and to assess if any changes to the strategy will impact on the disposal of the ICIA wastes
- a demonstration that all HAW arisings from the UK HPR1000 will be disposable based on the advice from Radioactive Waste Management Ltd (RWM)

Any Assessment Findings (Appendix 2), would be addressed by a future operator at an appropriate point during the plant procurement, design development, construction or commissioning programme. These Assessment Findings may relate to:

- matters that are normally addressed during the construction or commissioning phase (for example, demonstration that as-built plant realises the intended design)
- matters that depend on site-specific characteristics

5. Management systems

This chapter covers our assessment of GNSL's management systems. A management system is 'the set of procedures an organisation needs to follow in order to meet its objectives'. It includes identifying the necessary organisational resources, responsibilities and capabilities.

At the time of writing, our assessment is that GNSL has an adequate management system in place, and is continuing to develop arrangements that will:

- ensure the design achieves high standards of protection of people and the environment
- control the content and accuracy of the information provided for GDA
- control and document modifications to the design
- ensure appropriate transfer of information to potential operators

During our detailed assessment, we have identified one potential Assessment Finding and one potential GDA Issue.

Assessment Finding 1: The future site operator shall develop arrangements for managing GDA assessment findings, requirements and assumptions relating to environmental aspects of the design.

Potential GDA Issue 1: The Environment Agency and ONR have identified shortfalls across UK HPR1000 safety case documentation in identifying and using operating experience (OPEX). We expect relevant OPEX to be identified and considered to support the development of environmental protection functionality in the design, consistent with applying best available techniques (BAT).

It should be noted that the RP has committed to improving its OPEX arrangements in line with a resolution plan developed following Regulatory Observation RO-UKHPR1000-0044.

We want to ask you:

Consultation question 1:

Do you have any views or comments on our preliminary conclusions on management systems?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Matters arising from our initial assessment

We examined GNSL's management system in some detail during our initial assessment in 2018 (Environment Agency, 2018a) and concluded that GNSL and its service providers have sufficient suitably skilled resources, and employ appropriate and adequate management systems and quality assurance arrangements, to develop the UK HPR1000 generic design and associated safety case documentation.

Although we considered that the arrangements were satisfactory for that stage of the GDA process, we noted that some of these organisational and management arrangements were still being implemented, and the effectiveness of working arrangements was still evolving.

These aspects were noted for follow-up in the detailed assessment stage, and are addressed in the following sections.

Other aspects of our detailed assessment

During the detailed assessment stage, we have continued to scrutinise GNSL's management arrangements. As well as the matters discussed above, we have re-examined some of the arrangements and assessed some for the first time, as set out below.

Our detailed assessment work on this topic area has been carried out jointly with the Office for Nuclear Regulation (ONR). The findings from inspections carried out in the detailed assessment stage up to 30 June 2020 are reported in ONR Contact Records ONR-NR-CR-19-029, ONR-NR-CR-19-183, ONR-NR-CR-19-312, and ONR-NR-CR-19-507.

Organisational capacity and capability

GNSL and its service providers (CGN and EDF) continue to have adequate numbers of suitably qualified and experienced people available to support the development of the UK HPR1000 design and the associated GDA submissions. This includes using specialist contract organisations to provide support in ensuring that the design and safety case meet UK context expectations.

Management and quality assurance

GNSL is not certified to internationally-recognised management standards such as ISO9001 and 14001, but uses equivalent arrangements that are audited by a certified external auditor. Management procedures and associated documentation are now fully developed and implemented. We are satisfied that management system and quality assurance arrangements are adequate for the UK HPR1000 GDA project.

Design management and design change control

GNSL has formal arrangements in place for design development, configuration management and design change control. These arrangements are integrated with equivalent arrangements used by CGN as the designer. We assessed the effectiveness of these arrangements and although most were satisfactory, we found some shortcomings in relation to the specified requirements for design change review, and how well the process was applied. Regulatory Observation RO-UKHPR1000-0024 was raised on this matter. We have subsequently confirmed that GNSL has introduced appropriate changes to the relevant procedures, and at the time of writing is in the process of implementing these arrangements. We will continue to keep these arrangements under review through the remainder of the GDA process.

Arrangements to transfer information to a future licensee

GNSL has developed processes for transferring the UK HPR1000 technology to a future operator. At the time of writing, these arrangements are still being developed and implemented, and we expect this process to continue through the remainder of this project. We have reviewed these arrangements as part of our detailed assessment inspection at GNSL and as part of ongoing meetings with the Requesting Party. Overall, we are satisfied that GNSL is making adequate progress in this area.

Safety case management

GNSL has formal arrangements in place for development and quality assurance of the safety case, enough for their submission to satisfy the requirements and expectations set out in our GDA Process & Information Document (P&ID).

As part of our detailed assessment, we have scrutinised the safety case management arrangements and concluded that overall, they appear to be adequate. We have identified some shortcomings relating to identifying and recording safety case commitments, requirements and assumption; and using operating experience (OPEX). Regulatory Observations RO-UKHPR1000-0004 and RO-UKHPR1000-0044 respectively address these issues, and, at the time of writing, the Requesting Party is progressing with resolution plans to address these observations. We have identified one potential GDA Assessment Finding and one potential GDA Issue corresponding to these observations.

Assessment Finding 1: the future site operator shall develop arrangements for managing GDA assessment findings, requirements and assumptions relating to environmental aspects of the design.

Potential GDA Issue 1: The Environment Agency and ONR have identified shortfalls across UK HPR1000 safety case documentation in identifying and using operating experience (OPEX). We expect relevant OPEX to be identified and considered to support the development of environmental protection functionality in the design, consistent with applying best available techniques (BAT).

Our overall preliminary conclusions on management systems

At the time of writing, some elements of GNSL’s GDA management and quality arrangements are continuing to be developed and implemented. Nevertheless, at this stage, we can conclude that GNSL has a management system in place that will:

- address protection of people and the environment in the development of the UK HPR1000 design
- control the content and accuracy of the information provided for GDA
- control and document modifications to the design
- ensure appropriate transfer of information to potential operators

We have identified one potential GDA Issue and one Assessment Finding, as set out in the above paragraphs and at the beginning of this chapter. GNSL has committed to addressing any matters by the end of GDA. We will monitor its progress on these commitments as we continue to assess GNSL’s management and quality arrangements through the remainder of the UK HPR1000 GDA project.

More details of our assessment of management systems can be found in our assessment report 'Preliminary detailed assessment of management systems for General Nuclear System's UK HPR1000 design - AR01’ (Environment Agency 2021a).

6. Strategic considerations for radioactive waste management

This chapter covers our assessment of the strategic considerations given by GNSL to radioactive waste management, in developing the design. This includes its general approach to producing and managing radioactive waste and, in particular, its approach to the longer term issues of decommissioning and dealing with spent fuel.

Our preliminary conclusions are that:

- General Nuclear System Limited has provided an acceptable waste strategy for all waste streams in the scope of GDA that a UK HPR1000 would be expected to produce throughout its life cycle. The details underpinning the Integrated Waste Strategy (IWS) in this respect are considered in greater detail in our relevant assessment reports for individual waste streams and disposability (Environment Agency, 2021c, d & e).
- General Nuclear System Limited's IWS, together with its other submissions, will help to ensure proper protection of people and the environment. The details underpinning the IWS in this respect are considered in greater detail in our assessment report on the assessment of doses to the public and to wildlife (Environment Agency, 2021g)
- The IWS is consistent with relevant guidance, government policy statements (DECC, 2014) and current regulatory expectations (subject to RQ-UKHPR1000-0946).

We have identified no potential GDA Issues and one Assessment Finding.

Assessment Finding 2: If a future site operator has multiple sites, an assessment of BAT should be produced which covers all of its sites, noting the proximity principle, economies of scale and other efficiencies in disposal of solid and incinerable liquid wastes. The assessment should form part of a future operators submissions for its second and subsequent environmental permit applications.

We want to ask you:

Consultation question 2:

Do you have any views or comments on our preliminary conclusions on strategic considerations for radioactive waste management?

Please read below for a summary of our detailed assessment and links to further supporting documents.

General approach to radioactive waste management

Our Radioactive Substances Regulation Environmental Principles (REPs) (Environment Agency, 2010), at principle RSMDP1 (Radioactive substances strategy), indicate the matters to be considered at a strategic level. In addition, we expect an IWS to also consider all the regulatory expectations in our P&ID (Environment Agency, 2016), government policy statements (DECC, 2014) and to make reference to the specification and guidance provided by the NDA (NDA, 2012).

Our assessment is based mainly on the Integrated Waste Strategy (IWS) document submitted by the RP (GNSL, 2020c). At the time of writing, the current version was revision F. The development of an integrated waste strategy is introduced in the 'Pre-Construction Environmental Report, Chapter 4 - Radioactive Waste Management Arrangements' (GNSL, 2020a). It is important to note that there are significant overlaps with some of our other assessment reports, most notably 'AR05 - Solid waste, spent fuel and disposability' (Environment Agency, 2021e) and 'AR03 - Best available techniques for minimising production and disposal of radioactive waste' (Environment Agency, 2021c).

The UK HPR1000 IWS has been derived for a single reactor unit situated at a generic site.

GNSL covers the following aspects in the scope of its IWS (GNSL, 2020c):

- the facilities that generate, store, treat and process the wastes and waste packages
- design features that have been incorporated to prevent or minimise waste arising
- design features that have been incorporated to monitor and minimise the radioactive and non-radioactive discharges
- UK HPR1000 waste management principles and how they align with UK national policies and regulatory context
- outline of UK HPR1000 waste management organisation and arrangements to ensure that the wastes can be managed safely and in an environmentally responsible manner
- engagements with external stakeholders in developing this integrated strategy
- how the approach to waste management is developed and optimised in an integrated way
- strategy for managing all radioactive, non-radioactive waste and spent fuel, from construction through operation to decommissioning
- links to other underpinning documents and references
- areas requiring further development

We consider the scope of the IWS described above to be in line with current guidance.

The first principle of the RP's IWS is to apply the waste management hierarchy to all wastes and that this should be fundamental when considering subordinate strategies and processes.

GNSL describes a number of principles it has followed in developing the IWS. These include:

- using BAT to minimise the impact of discharges and disposals
- the importance of good characterisation, sorting and segregation at source to ensure subsequent effective disposal
- minimising waste
- optimising decay storage to reduce the activity of radioactive wastes
- using the 'concentrate and contain' principle where 'concentrate and contain' involves trapping the radioactivity in a solid, concentrated form for storage and eventual disposal rather than the 'dilute and disperse' option that involves the direct discharge of gaseous or liquid radioactivity into the environment (DECC, 2009a)

We consider the waste management principles presented by the RP to be appropriate for a nuclear power station Integrated Waste Strategy.

We, and ONR, have issued a number of Regulatory Queries (and ONR have issued one Regulatory Observation) throughout the GDA process to date in relation to IWS. The majority of these have been incorporated into revisions of the IWS which have all led up to the current revision F. We have one RQ (RQ-UKHPR1000-0946) which relates mainly to the management strategy for non-radioactive wastes that remains open at the time of writing.

As with any IWS based on a generic site there are some fundamental issues that cannot be resolved until a later stage. Most notably these relate to the proximity principle and economies of scale. We therefore consider the following Assessment Finding appropriate to ensure these important issues are addressed as the site-specific plans develop:

Assessment Finding 2: If a future site operator has multiple sites, an assessment of BAT should be produced which covers all of its sites, noting the proximity principle, economies of scale and other efficiencies in disposal of solid and incinerable liquid wastes. The assessment should form part of a future operators submissions for its second and subsequent environmental permit applications.

Higher activity waste and spent fuel

The government has indicated that new nuclear power stations should proceed on the basis that spent fuel will not be reprocessed, and that both spent fuel and intermediate level radioactive waste (ILW) will be disposed of to a geological disposal facility (GDF) when it is available (DECC, 2011). Since such disposals are unlikely to occur until late this century, this means that the strategy needs to consider on-site storage and management of both ILW and spent fuel for the lifetime of the power station, or an appropriate alternative.

We expect a spent fuel strategy to be in line with government policy (DECC, 2011 & 2014) and our REPS (Environment Agency, 2010).

The strategy presented by the RP in the IWS document is in line with the above requirements and consists of the following 3 stages:

- short-term storage in the spent fuel ponds
- interim dry storage on-site
- off-site disposal in a geological disposal facility

Our assessment of spent fuel (which is considered to be waste) is covered below in section 9 - solid radioactive waste and in our assessment report AR05 - solid waste, spent fuel and disposability (Environment Agency, 2021e).

Decommissioning

In line with government policy, we expect decommissioning of the plant to be considered at the design stage, with a view to ensuring that it can readily be carried out, while minimising the volumes of decommissioning wastes and minimising the impacts on people and the environment of decommissioning operations and the management of those wastes.

For decommissioning, in line with government policy (DECC, 2009b, 2011 & 2014) and our REPs (Environment Agency, 2010), we expect:

- the radioactive waste and spent fuel strategy to address decommissioning
- the design to use the best available techniques (BAT) to:
    - facilitate decommissioning

- minimise arisings of decommissioning waste
- minimise the impacts on people and the environment of decommissioning operations and managing decommissioning waste

The IWS includes consideration of decommissioning and introduces the decommissioning strategy. The details of the decommissioning strategy are developed in a number of supporting documents, which include a Preliminary Decommissioning Plan (GNSL, 2019a) and a Decommissioning Waste Management proposal (GNSL, 2020h).

The Preliminary Decommissioning Plan (GNSL, 2019a) presents the optioneering work carried out by the RP to determine that immediate, rather than deferred, decommissioning strategy is the preferred option.

The Decommissioning Waste Management proposal document (GNSL, 2020h) provides more detail on specific waste streams. In this document, the RP acknowledges that the majority of the decommissioning wastes will be different from the operational waste streams generated throughout most of the plant's life cycle. However, it should be noted that some waste streams will remain the same between operational and decommissioning phase (that is, ion exchange resins and filters).

Non-radioactive solid wastes (being out of scope of GDA) are only covered in the main IWS documents and are not developed any further in the supporting documents, which focus on radioactive decommissioning wastes.

Our assessment of decommissioning wastes is also covered below in section 9 - solid radioactive waste and in our assessment report AR05 - solid waste, spent fuel and disposability (Environment Agency, 2021e).

Our overall preliminary conclusions on strategic considerations for radioactive waste management

Our preliminary conclusions are that:

- General Nuclear System Limited has provided an acceptable waste strategy for all waste streams in the scope of this GDA that a UK HPR1000 would be expected to produce throughout its life cycle. The details underpinning the IWS in this respect are considered in greater detail in our relevant assessment reports for individual waste streams and disposability (Environment Agency, 2021 c, d & e)
- General Nuclear System Limited's IWS, together with its other submissions, will help to ensure proper protection of people and the environment. The details underpinning the IWS in this respect are considered in greater detail in our assessment report on the assessment of doses to the public and to wildlife (Environment Agency, 2021g)
- the IWS is consistent with relevant guidance, government policy statements (DECC, 2014) and current regulatory expectations (subject to RQ-UKHPR1000-0946)

We have identified no potential GDA Issues and one Assessment Finding, as set out in the above paragraphs and at the beginning of this chapter.

More details of our assessment of strategic considerations for radioactive waste management can be found in our assessment report AR02 (Environment Agency, 2021b).

7. Best available techniques for minimising production and disposal of radioactive waste

This chapter covers our assessment of GNSL's process for identifying BAT in relation to minimising production and disposal of radioactive waste.

Identifying BAT is the result of a process of optimisation, where minimising the generation and discharge of radioactive waste is balanced against the cost and benefits of further reductions. Applying the results of such a process leads to a design that is capable of meeting high environmental standards but where the cost of applying techniques is not excessive in relation to the environmental protection they provide.

We also look at the:

- sources of radioactivity in the reactor that will eventually become waste, and the techniques used to minimise the amount produced
- containment of radioactive substances in the plant, since losses can result in large volumes of radioactive waste and contamination of land or groundwater
- processing of radioactive substances in the plant and how this affects the distribution of radioactivity between gaseous, aqueous and solid waste streams

Our preliminary conclusion is that GNSL has followed an appropriate process for identifying BAT and that the UK HPR1000 uses BAT to:

- prevent and minimise the creation of radioactive waste
- support the principle of 'concentrate and contain'
- minimise the overall impact of discharges to the environment

We have identified 2 potential GDA Issues and 10 Assessment Findings:

Potential GDA Issue 2: GNSL has not yet provided a demonstration that selected options are optimised with respect to environmental protection and safety. We require GNSL to demonstrate that it has considered environmental aspects, alongside safety aspects, in order to achieve a design optimised for both.

Potential GDA Issue 3: GNSL has provided environmental justification for the choice of high efficiency particulate air filter design. However, further justification must be provided to demonstrate how best available techniques is applied.

Assessment Finding 3: A future operator shall develop arrangements for managing environment protection measures. This should include manufacturing, commissioning and operation, including examination, maintenance, inspection and testing requirements.

Assessment Finding 4: A future operator shall keep under review the possibility to remove secondary neutron sources or to optimise their design at the earliest occasion.

Assessment Finding 5: A future operator shall demonstrate that the UK HPR1000 will be operated in a way that represents best available techniques for the selection and change strategy of demineraliser resins for liquid waste management systems.

Assessment Finding 6: A future operator shall review and optimise water chemistry regimes presented during GDA to reduce waste generation.

Assessment Finding 7: A future operator shall demonstrate that the dissolved nitrogen level in the primary coolant is minimised.

Assessment Finding 8: A future operator shall review the practicability of techniques for abating carbon-14.

Assessment Finding 9: A future operator shall optimise the balance between gaseous, liquid and solid phase of carbon-14.

Assessment Finding 10: A future operator shall assess the chemical form of carbon-14 discharged to the environment and use this to inform future dose assessments.

Assessment Finding 11: A future operator shall assess the impact of its proposed operating fuel cycle on the radioactive waste generation and disposal before implementing any changes.

Assessment Finding 12: A future operator shall address the post-GDA forward action plans identified by GNSL in the 'Demonstration of BAT' submission, HPR/GDA/PCER/0003, Revision 001-1, October 2020 (GNSL, 2020j).

We want to ask you:

Consultation question 3:

Do you have any views or comments on our preliminary conclusions on the process for identifying BAT or on the techniques used to minimise production and disposal of radioactive waste?

Please read below for a summary of our detailed assessment and links to further supporting documents.

About BAT

There is a requirement under EPR16 that we exercise our functions to ensure that all exposures to ionising radiation of any member of the public and of the population as a whole resulting from the disposal of radioactive waste are kept as low as reasonably achievable (ALARA), taking into account economic and social factors. We do this by requiring designers and operators to use BAT to:

– prevent and minimise the creation of radioactive waste
– minimise the discharges of gaseous and aqueous radioactive waste to the environment
– minimise the impact of those discharges on people, and adequately protect other species, by ensuring doses to the environment are ALARA

Definition of BAT

Best available techniques means the latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicate the practical suitability of *a particular measure for limiting discharges, emissions and waste. In determining whether a set of processes, facilities and methods of operation constitute the best available techniques in general or individual cases, special consideration shall be given to:*

comparable processes, facilities or methods of operation which have recently been successfully tried out

technological advances and changes in scientific knowledge and understanding

the economic feasibility of such techniques

time limits for installation in both new and existing plants

the nature and volume of the discharges and emissions concerned

Techniques include both the technology used and the way in which the installation is designed, built, maintained, operated and dismantled.

(OSPAR)

NOTE - the above definition is used in our radioactive substances activity permits. The definition of BAT used in our installation activity permits comes from the Industrial Emissions Directive and has a slightly different wording.

BAT is a fundamental aspect of radioactive substances regulation, and we expect it to be identified by an appropriate process as described in our REPs (Environment Agency, 2010a) at principle RSMDP4 (methodology for identifying BAT) and in our principles of optimisation (Environment Agency 2010b).

GNSL's process for identifying BAT

We consider GNSL's approach to optimisation to be a suitable basis from which to identify BAT for the UK HPR1000 for GDA purposes. GNSL's main procedures for identifying BAT are the 'BAT Methodology' and 'Requirements on Optioneering and Decision-Making' submissions. Claims generated as part of this optimisation process are presented along with its accompanying arguments and evidence in the ‘Demonstration of BAT’ submission.

GNSL has suitably recognised the relevant principles of optimisation and sought to apply these in presenting the GDA case. The approach has also been guided by considering standard environmental permit conditions and P&ID requirements relating to optimisation (Environment Agency, 2016).

GNSL has also carried out a number of optioneering exercises to identify optimal approaches to the UK HPR1000 for GDA purposes. GNSL's approach to optioneering for UK HPR1000 is aimed at generating and evaluating options to address potential enhancements to the design, in accordance with the requirements for the use of BAT and for ONR, that risks are ALARP (as low as reasonably practicable). Optioneering exercises included gaseous, liquid and operational solid radioactive waste processing techniques and HEPA filter types. GNSL’s optioneering method and process has varied in terms of the specific approaches to scoring and sensitivity analysis. We recognise that different approaches are possible and consider that the approach GNSL adopted has been sensibly scoped and is in line with the GDA decision context. Overall, our preliminary conclusion is that GNSL has used optioneering approaches where appropriate, targeting those aspects that are relevant to the UK design and, where prompted, in response to specific regulatory considerations, for example, to justify specific design configurations. A Regulatory Observation concerning the choice of HEPA filter type remains open at this time and our preliminary conclusion is subject to the following potential GDA Issue:

Potential GDA Issue 3: GNSL has provided environmental justification for the choice of high efficiency particulate air filter design. However, further justification must be provided to demonstrate how best available techniques is applied.

GNSL's approach has been to set out claims, develop arguments in support of these, and to provide the relevant supporting evidence, where possible. The approach recognises that the UK HPR1000 is an evolution of earlier pressurised water reactor (PWR) technology and reflects on design improvements that are relevant to the BAT claims (as described by GNSL against specific BAT arguments, see Appendix 6 for further information). We consider this to be a sensible approach and a suitable method by which to convey the 'BAT case' for generic design assessment of the UK HPR1000.

GNSL's approach has also included identifying aspects relating to BAT that any future operators will need to action at the detailed design and permitting stage. These aspects have been identified as 'forward action plans' and captured as an Assessment Finding (Assessment Finding 12). We consider this to be a useful approach and recognise the value of these forward action plans.

Demonstrating that BAT has been applied to the design and operation of the UK HPR1000 means relevant factors, including safety aspects must be balanced. Therefore, optimisation must be based on an approach that considers both BAT and ALARP, where appropriate. We have concluded that the UK HPR1000 design is consistent with BAT in so far as this has been demonstrated and to a level in line with our expectations for GDA. However, we cannot yet make our final conclusion, as ALARP aspects of the design are yet to be fully demonstrated to ONR, as reflected in outstanding Regulatory Observations. In addition, limits and conditions of operation are yet to be fully defined for plant that has an environmental protection function. There remains a possibility, therefore, that design changes in response to ongoing ALARP considerations may impact on the design of plant and how it is to be operated. This may ultimately impact on the BAT case for the UK HPR1000.

We have concluded that BAT is adequately addressed in GNSL's design development processes. It is therefore anticipated that any design changes that may result from ongoing ONR ALARP considerations, will be appropriately assessed in terms of BAT. We will need to revisit our current preliminary conclusion pending any future design changes to the UK HPR1000 and once any operational limits and conditions are defined. We will continue to liaise with ONR on this, as part of the ongoing assessment, and this work will inform our final decision document.

Our preliminary conclusion is subject to the following potential GDA Issue:

Potential GDA Issue 2: GNSL has not yet provided a demonstration that selected options are optimised with respect to environmental protection and safety. We require GNSL to demonstrate that it has considered environmental aspects, alongside safety aspects, in order to achieve a design optimised for both.

Sources and minimisation of radioactivity

This section describes the sources of radioactive materials in the UK HPR1000 that will eventually become waste, and the techniques used to minimise the amount produced.

The majority of radionuclides in the reactor core are retained within the fuel and in the activated structures. However, a small amount of radioactivity can transfer from the fuel or structure into the primary coolant through leaks, diffusion or corrosion. A small proportion of those radionuclides in the primary coolant can then transfer to the secondary coolant system (in case of steam generator tube leaks), auxiliary systems and waste management systems. We have illustrated the sources and flow paths for radioactive wastes within the

UK HPR1000 in Figure 7-1 (a simplified diagram adapted from figures in the 'Demonstration of BAT' submission).

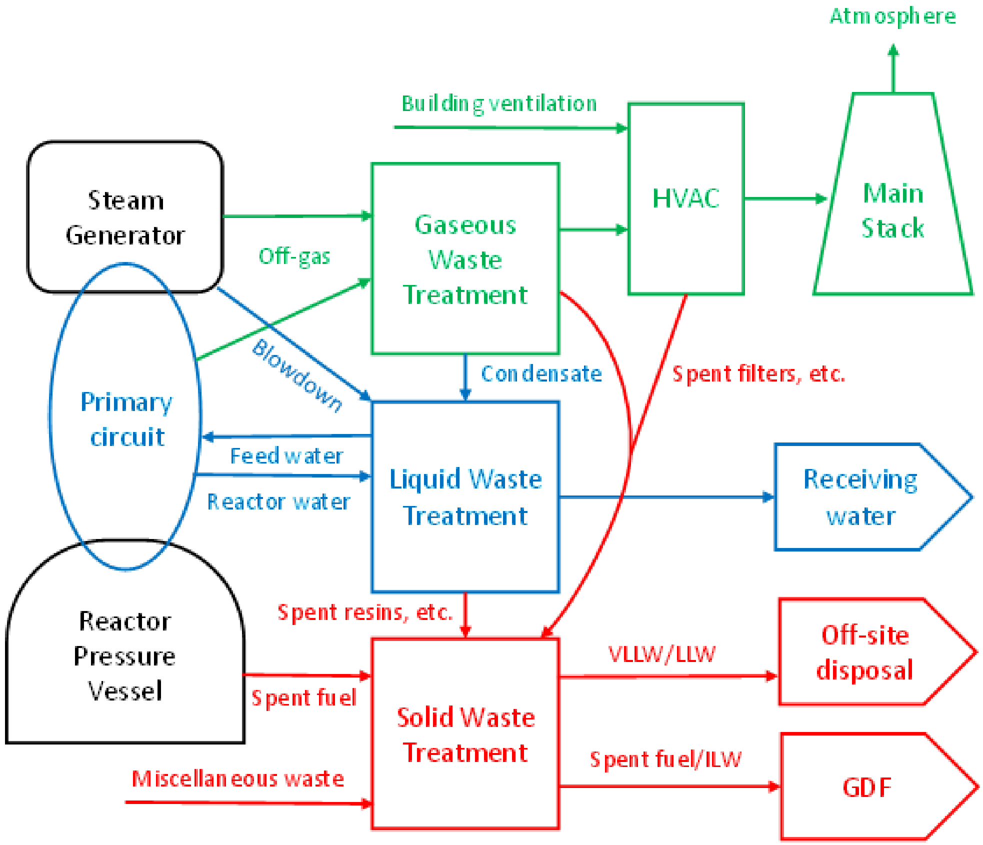

Figure 7-1: A simplified diagrammatic representation of the gaseous (green), liquid (blue) and solid waste (red) arisings within the UK HPR1000

GNSL has outlined how prevention and minimisation, and control and management of radionuclides generation and transport throughout the plant are optimised in the UK HPR1000 so as to minimise the levels of radioactivity. The origins of radioactivity within the UK HPR1000 and the measures for minimising the generation of radionuclides are mainly as follows:

- fission products and actinides leakage and generation from the fuel are minimised through optimised fuel and core design, fuel manufacturing, chemistry regime in the primary circuit and fuel operating management
- activation products from materials of structures, systems and components (SSCs) in contact with the primary coolant are minimised by using materials in which impurity elements have been minimised and controlled and by implementing an optimised chemistry water quality control
- activation of dissolved substances within the primary coolant are also minimised by implementing an optimised chemistry water quality control, for example tritium production is minimised by using boron (used to control reactivity) enriched in boron-10 and lithium hydroxide (used to adjust pH) enriched on lithium-7
- corrosion products from materials generated and suspended in the primary coolant are minimised by improved corrosion performance of selected materials and implementing an optimised chemistry regime

The demonstration of BAT for minimising and managing radioactive waste in the UK HPR1000 is presented in the 'Demonstration of BAT' submission and the supporting documentation. Based on the extensive documentation GNSL provided, our preliminary conclusion is that, at this stage, GNSL has identified the radionuclides that will contribute significantly to the amount of radioactivity in waste disposals that will result in doses to members of the public. A couple of Regulatory Observations (RO-UKHPR1000-0026 and RO-UKHPR1000-49) remain open at this time and the responses could influence the BAT demonstration for generating, minimising and managing radioactive waste in the UK HPR1000. We will review these responses before making our final decision.

GNSL claims that the UK HPR1000 design prevents and minimises the generation of radioactive waste. Claims, arguments and evidence in support of this are provided as part of the ‘Demonstration of BAT’ submission.

GNSL claims that the following aspects of the UK HPR1000 design help to prevent and minimise the generation of radioactivity in the core and primary circuit:

- design, manufacture and management of nuclear fuel to minimise the potential for a release of fission products from the fuel into the primary circuit
- management of core design and cycle length to minimise spent fuel during operation
- optimised design, an appropriate chemical water control and material selection to minimise the radioactivity of activated structures, the generation of corrosion products and activation products

GNSL claims that the following aspects of the UK HPR1000 design help to minimise the radioactivity in radioactive waste disposed to the environment, including applying the ‘waste management hierarchy’(avoid, reduce, reuse, recycle, disposal) related to the principle of ‘concentrate and contain’:

- a gaseous waste treatment system (GWTS) that includes processes to reduce radioactivity of short-lived fission products in the gaseous phase prior to discharge to the environment
- a heating ventilation and air conditioning (HVAC) system that prevents the uncontrolled discharge of radioactive substances
- treatment techniques for aqueous waste that minimise the discharge of radioactivity to the environment
- segregation and decay storage to minimise the radioactivity associated with wastes that require disposal

GNSL claims that the following aspects of the UK HPR1000 design help to minimise the volume of radioactive waste disposed of, to other premises:

- optimised design to minimise the volume of operational and decommissioning waste
- providing a number of features that will allow future operators to adopt an operating philosophy that will minimise the quantity of solid radioactive waste associated with routine operations and maintenance
- providing facilities with selected waste processing techniques for managing, treating and storing solid radioactive waste
- availability of a range of decontamination techniques during decommissioning

Containment of radioactive substances

Any radioactivity in the reactor that is not retained in the fuel will eventually end up as radioactive waste. However, the volume of waste produced can be minimised by containing the radioactivity within those parts of the plant where it is intended to be, and not allowing it to contaminate other parts of the plant, land or groundwater.

GNSL has provided a number of claims, arguments and evidence in support of the containment features of the UK HPR1000 design. We provide our views on each of the arguments presented in GNSL's 'Demonstration of BAT' submission in Appendix 6. Our preliminary conclusion, at this stage in GDA, is that the design of the UK HPR1000 is suitable to ensure containment of radioactive substances.

Processing of radioactive substances in the UK HPR1000

Once radioactivity is circulating in the reactor coolant, its subsequent processing and handling will determine its ultimate distribution between gaseous, aqueous and solid waste streams. We expect the techniques used to be consistent with the principle of the preferred use of 'concentrate and contain' in the management of radioactive waste over 'dilute and disperse' (GB Parliament, 2009a). This means that radioactive waste should preferentially be produced as, or converted to, a solid waste. We also expect BAT to be used to ensure that the distribution of any residual radioactivity between gaseous and aqueous waste streams minimises the overall impact of discharges to the environment.

GNSL has described how radioactive substances will be processed in the UK HPR1000 to ensure that waste is appropriately managed for disposal, considering the application of waste hierarchy, BAT and ALARP principles. We summarise the design features of the UK HPR1000 that apply to processing gaseous, liquid and solid wastes below.

We note that detailed operational aspects of relevance to the BAT case are not provided in the GNSL documentation at this time, although broad operational aspects are discussed. This is because the decision on how the reactor is operated sits with a future operator. The definition of ‘limits and conditions’ may provide some clarity on generic operational aspects for plant with an environmental protection function. We will expect further details as to how plant will be operated to ensure that BAT is applied in the site permitting phase.

Processing gaseous wastes

GNSL claims that design features of the UK HPR1000 ensure that the impacts of gaseous discharges are minimised. The UK HPR1000 design aims to avoid and reduce gaseous waste arisings, limit the concentration of radionuclides in gaseous wastes by using delay beds, and remove particulate material from gaseous waste using HEPA filtration. The main features of the design relevant to minimising the impact of gaseous discharges are as follows:

- the design, manufacture and management of nuclear fuel to minimise the potential for a release of fission products from the fuel into the primary circuit
- the prompt detection and in core management of failed fuel
- providing the GWTS that includes processes to reduce radioactivity in the gaseous phase prior to discharge to the environment
- providing delay beds within the GWTS to abate short lived fission products
- providing a HVAC system that prevents the uncontrolled discharge of radioactive substances

The GWTS is designed to collect and treat the process gaseous radioactive waste produced from the vessels, tanks and other equipment which contain the reactor coolant during normal operations. It continuously flushes nitrogen through the gas space of these vessels and tanks to control the hydrogen/oxygen concentration under the flammability limits. Delay beds are used to adsorb radioactive noble gases and iodine isotopes to allow time for the radioactive gases to decay to lower activity levels before leaving the system. The gaseous effluent from the GWTS is routed to the HVAC system where it is filtered by HEPA filters and iodine traps if needed (automatically put into operation when elevated concentrations of radioactivity are detected).

Gaseous effluent from building ventilation is managed by the HVAC system. This provides treatment for the radioactive aerosols and radioactive gases (including radioactive isotopes of iodine) in the gaseous effluent, using HEPA filters to remove particulate matter and iodine adsorbers, where appropriate, to remove radioactive isotopes of iodine.

The buildings that are within the detailed design scope of GDA and could potentially generate gaseous radioactive waste due to the inventories within them, are the reactor building, the nuclear auxiliary building and the fuel building. Further buildings outside the 'reactor island' and not subject to detailed design in GDA, including the conceptual radioactive waste stores, are also likely to generate small quantities of gaseous radioactive waste.

We observe the following at this stage:

- Using a modern and well established fuel design and further measures to reduce fuel failure rates will help minimise gaseous waste arisings by limiting releases from fuel failure. Measures to detect and manage fuel failure within the core should also prove effective in this regard. The regulators will seek to ensure that any future operators develop suitable arrangements to ensure that gaseous discharges are minimised by appropriate fuel management.
- Using delay bed technology is effective at reducing discharges of noble gases, consistent with applying BAT for such gases and consistent with approaches adopted in other light water reactors. Delay beds are also expected to have some benefit in reducing the concentration of short-lived iodine radionuclides. Our preliminary conclusion is that GNSL has demonstrated that the quantity of charcoal to enable delay and the management of the delay beds has been optimised in the UK HPR1000 design. However, aspects of the GWTS design are currently subject to further, specific consideration by the regulators and we will need to revisit this preliminary conclusion if any design changes were to adversely affect the efficiency of the abatement.
- The optioneering for the choice of HEPA filter for the UK HPR1000 design is currently the subject of a Regulatory Observation, which details the regulatory expectations, including expecting the optioneering study and justification of the choice of HEPA filter to comprehensively consider minimising gaseous radioactive discharges and solid waste arisings. They also need to consider energy use and the production and disposal of radioactive waste.
- The UK HPR1000 design aims to discharge gases and particulates at height via a main stack and this will help to minimise the impacts of those discharges. The height and location of the stack are a site-specific matter for the detailed design stage.
- We agree with GNSL that no abatement of tritium or carbon-14 is practicable at this time. We expect a future operator to review periodically any development worldwide of techniques that can be used to reduce the production of carbon-14 and to abate carbon-14 prior to discharge.

- We agree with GNSL that using a secondary neutron source (SNS) should be reviewed by a future operator to reduce the production of tritium.

Our preliminary conclusion is that, at this stage, the design of the UK HPR1000 is suitable for ensuring that BAT can be applied in minimising the impact of gaseous discharges.

We discuss the quantity of gaseous discharges to the environment further in Chapter 8.

Processing liquid wastes

GNSL claims that design features of the UK HPR1000 ensure that the impacts of liquid discharges are minimised. Relevant aspects are outlined in the ‘Demonstration of BAT’ submission. The UK HPR1000 design aims to avoid and reduce liquid waste arisings, ensure appropriate segregation, treatment and reuse of liquids, enable optimised use of filter and demineraliser technology, and use evaporators for liquids that require this treatment. The main features of the design relevant to minimising liquid discharges are as follows:

- The design, manufacture and management of nuclear fuel to minimise the potential for a release of fission products from the fuel into the primary circuit.
- The prompt detection and management of failed fuel.
- Treatment techniques within the liquid radioactive waste management system (LRWMS) that allow liquid to be reused within the plant and help to minimise the discharge of radioactivity to the environment. These technologies comprise filtration of solids, and using ion exchange (demineraliser) resins to remove ionic species and evaporators.
- The elimination or reduction of materials that are susceptible to activation at all stages of commissioning and operation. This prevents activation products forming that could contribute to liquid waste, or arise as components of solid waste.

The LRWMS is designed to collect, temporarily store, monitor and treat liquid radioactive waste prior to discharge. The LRWMS includes 2 drainage systems, the nuclear island vent and drain system which collects the drainage from the nuclear island, and the sewage recovery system which collects drainage from the radioactive waste treatment building, hot workshop and hot laboratory.

Most of the primary effluents will be reused, with a small amount discharged. To minimise the radioactivity of discharged primary effluents, the solids and soluble impurities in the reactor coolant are removed using filters and demineralisers before it is treated in an evaporator. During operation, the LRWMS will generate solid wastes that include waste termed as ‘concentrate’ and ‘sludge’, spent filters and spent ion exchange resins. The solid wastes will be treated and disposed of via the solid radioactive waste management system.

Detecting abnormal conditions and subsequent alarms as well as operational procedures protect against accidental discharge. System components such as tanks, processing equipment, pumps, valves, and instruments that may contain radioactivity are arranged in appropriate containment to prevent or minimise release to the environment.

At decommissioning, the water within the reactor and fuel pool systems will be treated and discharged using the systems identified above as far as practicable, including liquid effluents arising from decontamination and dismantling activities. Redundant items of plant and equipment will be managed according to the solid radioactive waste management system.

The final discharge line receives liquid disposals from 2 sampling locations, one in the nuclear island liquid waste discharge system and the other in the conventional island liquid waste discharge system. Each of these systems contains 3 storage tanks which provide redundancy and time for sampling of the liquid effluent before discharge.

We observe the following at this stage:

- Using a modern and well established fuel design, and further measures to reduce fuel failure rates, will help minimise liquid waste by limiting releases from fuel failure. Measures to detect and manage fuel failure should also prove effective in this regard. The regulators will seek to ensure that any future operators develop suitable arrangements to ensure that liquid discharges are minimised by appropriate fuel management.
- The UK HPR1000 design enables clean-up and reuse of liquids within the plant, therefore avoiding unnecessary discharges.
- The UK HPR1000 uses filters, demineraliser and evaporator technology to remove radioactivity from liquids. In our view, using these technologies is appropriately targeted at segregated liquids within the plant systems. This transfers the radioactivity to solid waste, consistent with a ‘concentrate and contain’ approach.
- No abatement of aqueous tritium is practicable. We agree with GNSL that it would be grossly disproportionate to use techniques at this time to avoid aqueous disposals of tritium, given the small dose impact (see Chapter 11: Impact of radioactive discharges).

Our preliminary conclusion is that BAT is applied to aqueous radioactive discharges from the UK HPR1000 and at the current time it is BAT not to abate tritium in aqueous discharges.

We discuss the quantity of non-radioactive liquid discharges to the environment further in Chapter 8.

Processing solid wastes

Solid radioactive wastes are produced during the operational and decommissioning phases of a power station’s life cycle. The UK HPR1000 design has a waste management strategy and system based on available treatment technologies and current and assumed future disposal facilities (see Chapter 6). The nature of the solid wastes that will arise in the UK HPR1000 is described further in Chapter 9.

The solid waste treatment system is designed to collect, segregate, treat, condition, package and store various types of operational solid radioactive wastes which are categorised as high level waste (HLW), intermediate level waste (ILW), low level waste (LLW) and very low level waste (VLLW) before being transported off-site. GNSL describes facilities capable of treating, interim and decay storing, where appropriate, and managing the disposal of solid radioactive wastes in accordance with the chosen options for managing these wastes, as described in GNSL's 'Radioactive Waste Management Arrangements' submission.

Our overall preliminary conclusions on preventing and minimising the creation of radioactive waste

Our preliminary conclusion is that the UK HPR1000 has demonstrated that BAT can be used to:

- prevent and minimise the creation of radioactive waste
- support the principle of 'concentrate and contain'

– minimise the overall impact of discharges to the environment

We have identified 2 potential GDA Issues and 10 Assessment Findings, as set out at the beginning of this chapter and in Appendix 6.

More details of our assessment of BAT to prevent and minimise the creation of radioactive waste can be found in our assessment report AR03 (Environment Agency, 2021c).

8. Gaseous and liquid discharges of radioactive waste

This chapter covers our assessment of the RP's estimates of gaseous and liquid discharges and the proposed limits that the UK HPR1000 would comply with.

Our preliminary conclusions are that:

– GNSL has provided us with information on estimated gaseous and liquid discharges and proposed limits. It is clear how it has derived these discharge estimates and the estimates are supported by suitable evidence

– the proposed annual gaseous and liquid discharge limits for the UK HPR1000 are clearly derived, taking into account our limit setting guidance (Environment Agency, 2012)

– we consider that GNSL has demonstrated that the UK HPR1000 discharges and limits are generally comparable with international OPEX and previous GDAs. Where there are differences, we are satisfied that GNSL has provided reasonable explanations (subject to RQ-UKHPR1000-0843)

– the gaseous and liquid discharges from the UK HPR1000 would be capable of meeting the limits set out below (Tables 8-1 & 8-2)

Table 8-1. The proposed annual gaseous discharge limits (becquerel - Bq)

Radionuclide	Proposed annual limit (Bq)
Tritium (H-3)	5.23E+12
Carbon-14 (C-14)	1.69E+12
Noble gases	1.56E+13
Xennon-133 (Xe-133)	1.16E+13
Xennon-135 (Xe-135)	3.45E+12
Halogens	2.21E+08
Other radionuclides	1.12E+07

Table 8-2. The proposed annual liquid discharge limits (Bq)

Radionuclide	Proposed annual limit (Bq)
Tritium (H-3)	1.04E+14
Carbon-14 (C-14)	5.90E+10
Other radionuclides	1.04E+09

We have identified no potential GDA Issues and one Assessment Finding.

Assessment Finding 13: A future operator shall keep the headroom factors derived during GDA under review. Operational data generated by the UK HPR1000 should be used to periodically revise the headroom factors to ensure they are minimised as much as possible.

We want to ask you:

Consultation question 4:

Do you have any views or comments on our preliminary conclusions on minimising the discharges and impact of gaseous and liquid waste, and our proposed limits and levels?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Sources of gaseous and liquid radioactive waste

We expect new nuclear power stations to use BAT to minimise the radioactivity in discharges of gaseous and liquid radioactive waste, and to minimise the impact of those discharges on the environment. Applying BAT is covered in section 7 above and our assessment report on best available techniques (Environment Agency, 2021c).

Information on the sources of gaseous and liquid radioactive wastes, quantification of arisings and discharges, and GNSL's proposed limits is provided in: 'Pre-Construction Environmental Report, Chapter 6, Quantification of Discharges and Limits v1.1' (GNSL, 2020e).

In this section 'liquid radioactive wastes' refers to aqueous liquid radioactive wastes only, which excludes non-aqueous liquid wastes such as oils. Where reference is made to 'gaseous wastes', these may include some particulates.

Gaseous radioactive wastes

There are 3 main systems that handle gaseous radioactive waste:

- gaseous waste treatment system (GWTS)
- heating ventilation and air-conditioning (HVAC) system
- condenser vacuum system (CVS)

All 3 systems combine in the HVAC system for discharge to air through a single site main stack. The gaseous effluent discharge routes have been summarised by GNSL in the following diagram:

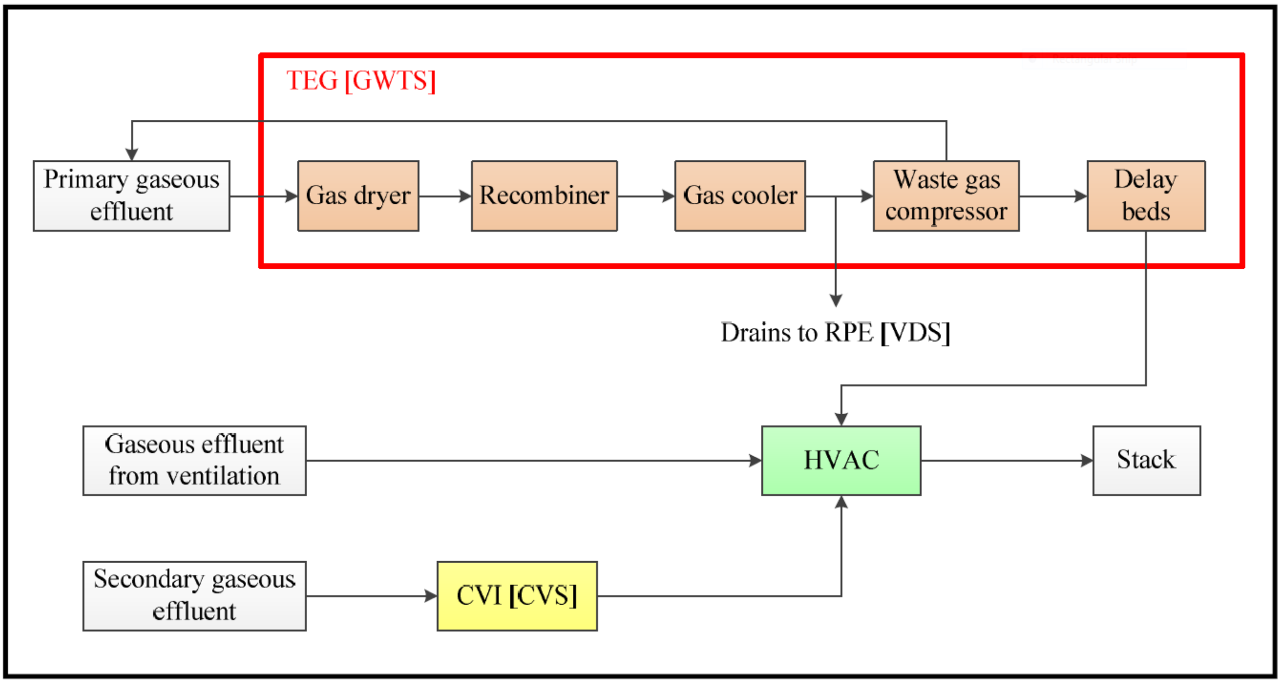

Figure 8-1: Radioactive gaseous effluent streams (GNSL, 2020e, section 6.4)

The diagram shows how the 3 systems link together to treat and manage the 3 categories of gaseous effluents; primary effluent, gaseous effluent from ventilation and secondary effluent (Figure 8-1).

The main site stack is the single emission point for gaseous radioactive waste. The waste stream is monitored continuously to collect data to demonstrate compliance with the discharge limits which will be included in a radioactive substances environmental permit for a future site. We assess sampling and monitoring in section 10 below and our assessment report on monitoring (Environment Agency, 2021f).

The treatment techniques used in the gaseous waste management system are the delay beds in GWTS and high efficiency particulate air (HEPA) filters in the HVAC system. There is also the option to use iodine traps in the HVAC system if necessary.

Liquid radioactive wastes

Liquid radioactive wastes go through a number of collection and treatment systems before being discharged into the environment. All of the liquid effluents described here flow to the ‘seal pit’ before being discharged through a single site outfall. The seal pit is a structure designed to prevent air getting back into the cooling water and effluent systems and is linked to the main site outfall into the environment.

The system can be summarised in the following diagram (Figure 8-2):

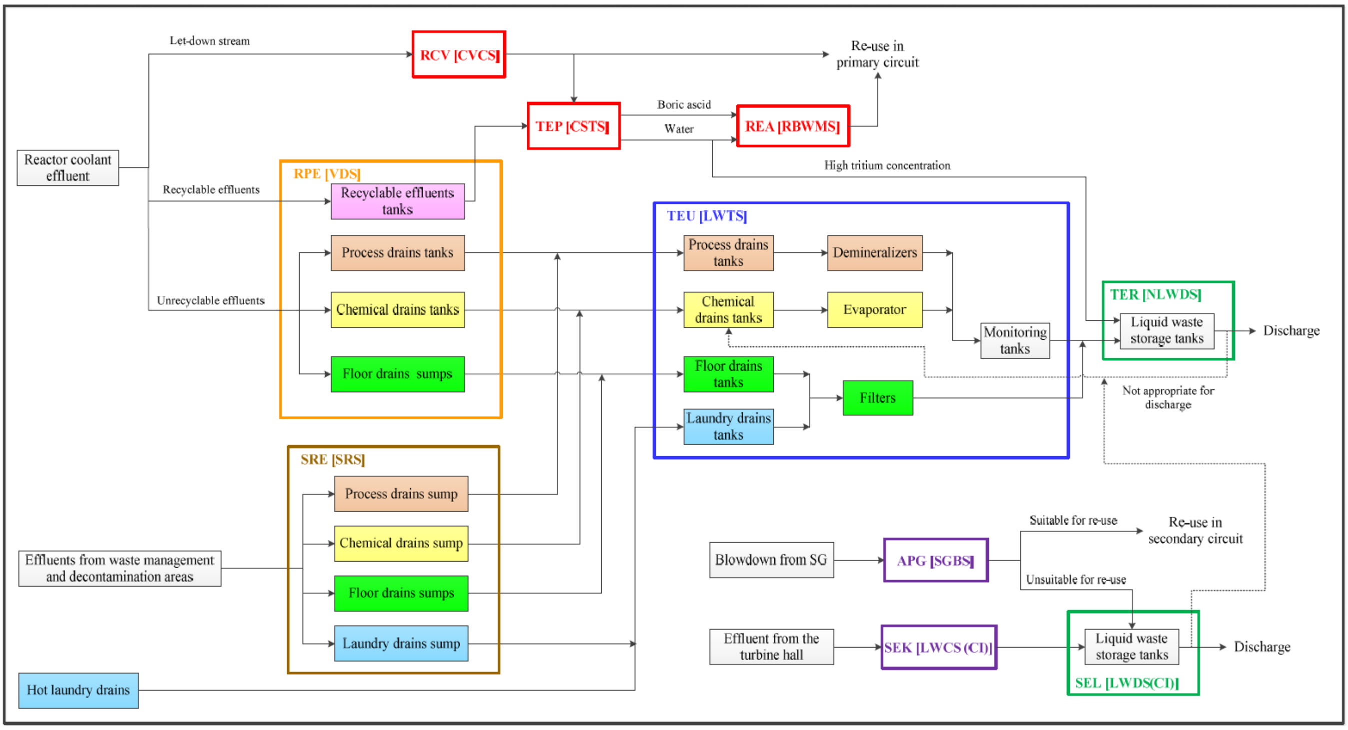

Figure 8-2: Radioactive liquid effluent streams (GNSL, 2020e, section 6.4)

The liquid waste streams can be divided into 3 categories; reactor coolant effluent, effluents from waste management and decontamination areas and secondary circuit effluent (steam generator blow-down and turbine hall effluent).

The treatment options used in the liquid waste treatment system (LWTS) are filtration, demineralisation and evaporation. These liquid treatment techniques are consistent with those used widely in similar nuclear power stations.

Our assessment of GNSL's method for quantifying discharges and limits

The main elements of GNSL's method for quantifying discharges and limits are as follows:

- defining operating conditions
- identifying significant radionuclides
- deriving correction factors
- deriving headroom factors
- deriving appropriate expected events

Each of the above elements generate radionuclide specific information that is used to calculate discharge estimates and limits.

We identified a number of shortfalls in our first full assessment of the information GNSL submitted and issued a Regulatory Observation (RO-UKHPR1000-0010). The approach GNSL used did not initially follow the regulatory expectations set out in our P&ID (Environment Agency, 2016), so in the RO we asked GNSL to revise how it had approached using OPEX, its calculation method and the presentation of data. Detail of the RO can be found in our assessment report 'Preliminary detailed assessment of gaseous and liquid discharges of radioactive waste for GNSL's UK HPR1000 design' (Environment

Agency, 2021d). After GNSL had carried out further work, we were able to close the RO in June 2020.

We have issued a number of Regulatory Queries throughout the GDA process to date. The majority of these have been incorporated into revisions of the documents that make up GNSL's submission. We have one RQ (RQ-UKHPR1000-0843) that remains open at the time of writing.

Operating conditions - GNSL defines the operating conditions used for quantifying discharges and limits to be routine operation, start-up and shutdown, maintenance and testing, and expected events. These operational conditions were further refined into one of two operational states, either 'power operation' or 'shutdown'. GNSL clearly defines which operating conditions apply in each operational condition.

GNSL's approach was to source its data from OPEX rather than theoretically deriving it from a source term calculation. This meant it was not possible to separate out each of the above aspects exactly as required by the P&ID (Environment Agency, 2016). We do however, consider the way the data have been presented to be acceptable as it satisfies the main intent of the P&ID requirements.

Significant radionuclides - GNSL has used our guidance on limit setting (Environment Agency 2012) to derive a set of 'significant radionuclides'.

Correction factors were derived to account for any differences between OPEX data and the UK HPR1000 design proposals.

Headroom factors are important to take account of the uncertainty in the OPEX data used to derive the discharge limits. They enable a future operator to comply with the proposed limits without unduly affecting its ability to operate the plant. We require headroom factors to be minimised as much as possible. We acknowledge that there may be considerable uncertainty in data presented at GDA stage, so we consider the following assessment finding appropriate to ensure the headroom is the minimum necessary to permit normal operation of the power station.

Assessment Finding 13: A future operator shall keep the headroom factors derived during GDA under review. Operational data generated by the UK HPR1000 should be used to periodically revise the headroom factors to ensure they are minimised as much as possible.

Expected events - GNSL provided a list of 'expected events' relevant to operating a UK HPR1000. Expected events are classed as a 'normal operation' and are therefore in scope of GDA and form part of our approach to setting permit limits on discharges to the environment. Other events inconsistent with using BAT (such as accidents or inadequate maintenance) are not considered 'normal operation' and therefore don't form part of our assessment at GDA.

We consider the methods used and conclusions reached by GNSL in relation to establishing operating conditions, significant radionuclides, correction factors, headroom factors and contribution of expected events to be reasonable. More detail of our assessment of each element can be found in 'Preliminary detailed assessment of gaseous and liquid discharges of radioactive waste for GNSL's UK HPR1000 design' (Environment Agency, 2021d). As stated above, each of the above elements generate radionuclide specific information that is entered into the formulae used to calculate discharge estimates and limits.

The specific outputs of the calculations were:

– estimated monthly discharges

– estimated annual discharges

These discharge estimates were then used to calculate:

– annual discharge limits

Calculations are also presented to derive maximum monthly discharge estimates. These provide an indication of possible variation in short term discharges during normal operation which would remain within specified annual limits. These can be caused by expected events and variation in plant parameters – leading to short term increases in discharges which can potentially affect the radiological impact. The maximum monthly discharges presented are used solely as an input to the radiological impact assessment of a short duration release – which is included in 'PCER Chapter 7 - Radiological Assessment'. Our view on this assessment is presented in section 11 below and our preliminary assessment report on radiological impact (Environment Agency, 2021g).

We have assessed GNSL's calculations used to derive discharge estimates and limits and are satisfied that our limit setting guidance (Environment Agency, 2012) has been followed and that the P&ID requirements have been met (Environment Agency, 2016). The estimated discharges and proposed limits are as follows (Table 8-3 and Table 8-4):

Table 8-3. Estimated discharges and proposed limits for gaseous discharges (Bq).

Radionuclide	Monthly discharges during power operation (Bq)	Monthly discharges during shutdown (Bq)	Annual discharge (Bq)	Proposed annual limit (Bq)
H-3	4.71E+10	1.82E+11	8.34E+11	5.23E+12
C-14	1.75E+10	9.91E+10	3.74E+11	1.69E+12
Noble gases	6.69E+10	2.71E+11	1.21E+12	1.56E+13
Xe-133	5.00E+10	2.02E+11	9.04E+11	1.16E+13
Xe-135	1.48E+10	5.99E+10	2.68E+11	3.45E+12
Halogens	4.79E+05	6.33E+06	1.75E+07	2.21E+08
Other radionuclides	3.15E+05	3.58E+05	3.86E+06	1.12E+07

Table 8-4. Estimated discharges and proposed limits for liquid discharges (Bq).

Radionuclide	Monthly discharges during power operation (Bq)	Monthly discharges during shutdown (Bq)	Annual discharge (Bq)	Proposed annual limit (Bq)
H-3	1.63E+12	5.27E+12	2.69E+13	1.04E+14
C-14	7.67E+08	3.71E+09	1.51E+10	5.90E+10
Other radionuclides	1.84E+07	7.49E+07	3.33E+08	1.04E+09

Comparison of UK HPR1000 discharges with other similar reactors around the world

GNSL has provided a comparison of the discharge estimates and limits derived above with other similar reactors worldwide.

GNSL approached this by carrying out a comparison with previous PWR GDAs and then with other international OPEX (UK, France, Germany & USA).

Information related to the comparison can be found in GNSL's Pre-Construction Environmental Report Chapter 6 (GNSL, 2020e).

GNSL reviewed the publicly available information on the previous GDAs for the UK EPR and the UK AP1000. Acknowledging the difference in approaches for quantifying discharges and limits used by the 3 RPs, GNSL carried out an indicative comparison of the data normalised to 1000 mega-Watt electrical power (MWe). This is an acceptable approach as it enables as meaningful a comparison as possible to be carried out. For example, discharges of gaseous tritium (H-3) and carbon-14 (C-14) are both proportional to power output, so normalising the data to 1000MWe enables these radionuclides to be compared. The results show that for all radionuclides, except gaseousH-3 and C14 and liquid tritium (H-3) the UK HPR1000's discharges are the same or slightly lower than the other PWRs. GNSL considers that this is likely to be due to the varying assumptions made between the 3 GDAs. GNSL asserts that the different approaches are specifically due to headroom factors and expected events. We considered that better justification was necessary and issued RQ-UKHPR1000-0843 to request this. The RQ remains open at the time of writing and we will assess the response when we receive it.

In order to make a meaningful comparison with international OPEX, GNSL took the annual averages from the international OPEX and the annual discharge estimates from the UK HPR1000 and then normalised them to 1000 MWe. The UK HPR1000 annual discharges are broadly similar to the international OPEX from similar plants around the world. Where differences are evident, GNSL has provided a number of considerations and conclusions to explain the variance (GNSL, 2020e). We have described this in more detail in our 'Preliminary detailed assessment of gaseous and liquid discharges of radioactive waste for GNSL's UK HPR1000 design' (Environment Agency, 2021d).

We consider that the information GNSL provided in this section demonstrates that the UK HPR1000 discharges and limits are generally comparable with international OPEX and previous GDAs. Where there are differences, we are satisfied that GNSL has provided reasonable explanations (subject to the outstanding RQ response).

Our overall preliminary conclusions on gaseous and liquid radioactive waste

Our preliminary conclusions are that:

- GNSL has provided us with information on estimated gaseous and liquid discharges and proposed limits. It is clear how it has derived these discharge estimates and the estimates are supported by suitable evidence
- the proposed annual gaseous and liquid discharge limits for the UK HPR1000 are clearly derived, taking into account our limit setting guidance (Environment Agency, 2012)
- we consider that GNSL has demonstrated that the UK HPR1000 discharges and limits are generally comparable with international OPEX and previous GDAs. Where there are differences, we are satisfied that GNSL has provided reasonable explanations (subject to RQ-UKHPR1000-0843)

– the gaseous and liquid discharges from the UK HPR1000 would be capable of complying with the limits set out below (Tables 8-5 & 8-6)

Table 8-5. The proposed annual gaseous discharge limits (Bq)

Radionuclide	Proposed annual limit (Bq)
H-3	5.23E+12
C-14	1.69E+12
Noble gases	1.56E+13
Xe-133	1.16E+13
Xe-135	3.45E+12
Halogen	2.21E+08
Other radionuclides	1.12E+07

Table 8-6. The proposed annual liquid discharge limits (Bq)

Radionuclide	Proposed annual limit (Bq)
H-3	1.04E+14
C-14	5.90E+10
Other radionuclides	1.04E+09

We have identified no potential GDA Issues and one Assessment Finding, as set out in the above paragraphs and at the beginning of this chapter.

More details of our assessment of gaseous and liquid discharges of radioactive waste can be found in our assessment report AR04 (Environment Agency, 2021d).

9. Solid radioactive waste

This chapter covers our assessment of:

- the techniques used to minimise the mass/volume of solid radioactive waste
- the proposed disposal routes for lower activity solid waste
- the management of higher activity solid waste and spent fuel

Minimising the quantity (mass and volume) of solid waste means better use can be made of the limited disposal facilities that are available. It also minimises the environmental impacts of transporting the waste to those facilities.

Currently, there are no disposal facilities for higher activity wastes and spent fuel, but it is government policy expected that these will be disposed of to a geological disposal facility (GDF) that the government intends to construct (DECC, 2011). The wastes and spent fuel need to be suitably managed until the GDF is available.

We include non-aqueous liquid wastes, such as oils and solvents, in our assessment of solid wastes, since they need to be managed and disposed of in similar ways.

Our preliminary conclusions are that:

- all solid wastes and non-aqueous wastes have been identified
- a good description of the quantities, activities and composition for the majority of the solid wastes and spent fuel arisings has been provided. Further information will be provided by the end of GDA
- generally a good description of how solid wastes and spent fuel arisings will be minimised at source is provided. However, there are a number of outstanding ROs and RQs that we are confident will be addressed before the end of GDA
- all LLW arisings from the UK HPR1000 would appear to be disposable. However, we have questioned whether the approach to LLW concentrates and sludges is BAT. There are a number of outstanding issues for a future operator to address, but these are site-specific
- we continue to assess whether the design of the UK HPR1000 has considered decommissioning and therefore minimised the generation of solid wastes. We are confident that GNSL will achieve this before the end of GDA
- we are confident that GNSL can apply effective characterisation and segregation to the solid wastes for the UK HPR1000. However, a future operator will need to demonstrate that BAT is being applied
- we are confident that the conditioning and packaging options chosen for the HAW solid wastes can potentially provide disposable products, however RWM continues to assess these options
- we are confident that if RO-UKHPR1000-0040 on the interim ILW store is addressed that GNSL will have demonstrated that the conceptual design for the ILW store will be BAT and that the packages will be maintained in an environment that will ensure that they will be disposable
- we are confident that if GNSL address the GDA Issue with regard to long-term storage of the spent fuel, the spent fuel interim store (SFIS) design will maintain the integrity of the spent fuel assemblies and therefore the assemblies will be disposable in the future

- the management strategy for the in-core instrument assemblies (ICIAs) could change and therefore impact on our assessment. A change in strategy could impact on the disposal of the wastes. However, at the time of writing the report we see no reason why the packages would not be disposable
- we are confident that the waste packages GNSL proposed are likely to be disposable, however we will assess RWM's assessment and how GNSL addresses any actions arising from the assessment

We have identified 3 potential GDA issues and 14 Assessment Findings.

Potential GDA Issue 4: GNSL is required to provide information in relation to the long-term storage requirements for the spent fuel and to demonstrate that the conceptual design for spent fuel interim store (SFIS) will deliver these requirements.

Potential GDA Issue 5: GNSL is required to provide further substantiation of the proposed strategy for the management of in-core instrument assemblies (ICIAs) and if any changes to the strategy is decided, to assess the impact on the disposal of ICIA wastes.

Potential GDA Issue 6: GNSL is required to demonstrate that all higher activity waste (HAW) arisings from the UK HPR1000 will be disposable.

Assessment Finding 14: A future operator shall ensure that its characterisation programme will identify any hazardous materials and non-hazardous pollutants that will be associated with the waste inventory for the UK HPR1000.

Assessment Finding 15: A future operator shall assess whether there are benefits in periodic decontamination of the UK HPR1000 primary circuit and its related systems and auxiliary circuits with regard to minimising production of decommissioning wastes and their classification. The future operator should demonstrate that BAT is being applied.

Assessment Finding 16: A future operator shall ensure that the decommissioning plan is periodically reviewed to ensure that BAT is being applied with regard to decommissioning the UK HPR1000.

Assessment Finding 17: A future operator shall review periodically the options for the treatment and disposal of solid low level waste from the operation and decommissioning of the UK HPR1000. The future operator shall ensure that the options implemented are BAT and will meet the disposal facilities waste acceptance criteria.

Assessment Finding 18: A future operator shall periodically update the Radioactive Waste Management Case or equivalent documentation in accordance with the Environment Agency's and ONR's joint guidance, in order to demonstrate that the higher activity waste is being managed across the whole life cycle.

Assessment Finding 19: A future operator shall develop its characterisation strategy and approach to segregation for solid and non-aqueous wastes further at the detailed design stage, to ensure that it can demonstrate that BAT is being applied.

Assessment Finding 20: A future operator shall ensure that the proposed conditioning and packaging options for the higher activity wastes for the operational and decommissioning waste arisings from the UK HPR1000 are BAT.

Assessment Finding 21: A future operator shall develop arrangements for identifying and managing non-compliant waste packages, to ensure that only packages that are suitable for disposal will be transferred to a GDF.

Assessment Finding 22: A future operator shall ensure that it deploys BAT for the conditioning of the spent fuel, prior to transferring the spent fuel assemblies to the spent fuel interim store.

Assessment Finding 23: A future operator shall ensure that the monitoring and inspection of the spent fuel assemblies and canister, within the spent fuel interim store are BAT.

Assessment Finding 24: A future operator shall ensure that the strategy for managing failed fuel over the life time of the UK HPR1000 is BAT.

Assessment Finding 25: A future operator shall engage with the operators of the disposal facilities to ensure that their requirements are complied with for both low activity wastes' and higher activity wastes' records.

Assessment Finding 26: A future operator shall continue to secure international OPEX with regard to the dry storage of spent fuels and ensure that it applies learning from the international OPEX to the storage of the UK HPR1000 fuel arisings.

Assessment Finding 27: A future operator shall secure and use OPEX, including that available internationally, to ensure that BAT is used to decommission the UK HPR1000 and that the generation of radioactive solid waste is minimised and it is capable of being disposed of.

We want to ask you:

Consultation question 5:

Do you have any views or comments on our preliminary conclusions on the management and disposal of solid radioactive waste and spent fuel?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Sources of solid radioactive waste

Information on the sources of solid and non-aqueous liquid radioactive wastes and the amount expected to be produced is provided in:

- Pre-Construction Environmental Report, Chapter 4 Radioactive Waste Management Arrangements, HPR/GDA/PCER/0004, Revision 001-1 October 2020. (GNSL, 2020a)
- Pre-Construction Safety Report, Chapter 5 Reactor Core, HPR/GDA/PCSR/0005 Revision 001, January 2020 (GNSL, 2020i)
- Decommissioning Waste Management Proposal, GHX71500009DNFF03GN, Versions E, June 2020. (GNSL, 2020h)
- Activated Structures Source Term Supporting Report, GHX00800003DRDG03GN, Revision D, June 2020. (GNSL, 2020ab)

- Decommissioning Technical User Source Term Report, GHX0050009DNFP03GN, Version E, June 2020. (GNSL, 2020g)
- Solid Radioactive Waste Management Report Technical User Source Term Report, GHX0050008DNFF03GN, Revision C, November 2019. (GNSL, 2019c)
- Waste Inventory for Operational Solid Radioactive Waste, GHX00100069DNFF03GN, Revision D, June 2020. (GNSL, 2020d)

The following conclusions were highlighted within our initial assessment report:

- GNSL needed to provide information on the volume, activity and composition of the waste generated during operation and decommissioning of the reactor.
- GNSL needed to provide information on the expected number of fuel assemblies that will be produced over the lifetime of the reactor.

GNSL has outlined the sources and quantities of all solid and non-aqueous radioactive wastes that are likely to arise from the operation and decommissioning of the UK HPR1000 reactor, within its 'Pre-Construction Environmental Report on Radioactive Waste Management Arrangements' (GNSL, 2020a).

Operational waste arisings

For each waste stream, GNSL has summarised:

- the type of waste
- its chemical and physical properties
- its radioactive waste classification (in accordance with the UK classifications for radioactive waste)
- the average and maximum activities of the wastes streams
- the annual and lifetime arisings
- whether there will be any hazardous materials associated with the waste
- the major radionuclides associated with the waste

The major classes of radioactive wastes that will arise during the operational phase of the reactor's life cycle will be very low level waste (VLLW), low level waste (LLW), intermediate level waste (ILW) and high level waste (HLW).

The wastes that will arise from the operation of the UK HPR1000 are:

- ion exchange resins from the liquid treatment auxiliary systems, for example, the chemical volume control system (CVCS) and liquid waste treatment systems (LWTS)
- the steam generator blowdown systems (SGBS) resins, which arise from the purification of the blowdown from the steam generators
- concentrates which are produced from operating the evaporators in the liquid waste treatment auxiliary system (LWTS)
- sludges which accumulate within sumps and tanks of the auxiliary circuits and need to be washed out, for example, liquid waste treatment system, LWTS
- ventilation HEPA filters from the heating ventilation and air conditioning (HVAC) systems

– spent filters used within the auxiliary systems to protect the ion exchange resins, for example, within the spent fuel pool treatment system (SFPTS) and the LWTS
– dry active wastes, such as metals, combustible materials, personal protective equipment from everyday operations
– oil and solvents arising from maintenance operations and pumps

The non-fuel core component (NFCC) wastes will be discussed within the section on spent fuel and NFCCs.

The operational waste arisings are summarised below (Table 9-1):

Table 9-1. A summary of operational waste arisings from a UK HPR1000

Waste type	Classification	Annual arisings
Spent resins	ILW	1.9m^3
Spent resins	LLW	9.7m^3
Concentrates	LLW	1.47m^3
Concentrates	ILW	0.73m^3
Sludges	LLW	0.05m^3
Sludges	ILW	0.05m^3
Spent filters	LLW	0.65m^3
Spent filters	ILW	1.14m^3
Dry active waste	LLW	156.4m^3
Dry active waste	ILW	22.4m^3
Oils	LLW/VLLW	0.13m^3
Solvents	LLW/VLLW	0.2m^3
Ventilation filters	LLW	29.7m^3

The projected annual volume of VLLW/LLW that will arise from the UK HPR1000 is approximately 198m^3.

We queried the OPEX that GNSL had used to derive the average number of filters that will arise from the UK HPR1000, as in the data provided there were a series of step changes in the number of filters, which were used over the period from 2010 to 2013. GNSL responded that the step changes were due to a change in strategy with regard to the use of pre-filters. GNSL's response also provided additional information demonstrating that the filter arisings from the UK HPR1000 would be similar to those from other reactors which have been assessed through the GDA process. We are content with the response and that GNSL has updated the inventory.

We also raised a Regulatory Observation and Regulatory Query, to seek justification for using a rectangular HEPA filter instead of the cylindrical filter. The cylindrical filter is considered to be best practice within the UK. We are awaiting a response from GNSL, and will continue to assess this area as part of our ongoing assessment. If the filter type is changed we will expect the waste arisings to be optimised and to receive an update of the waste inventory before the end of GDA. We have raised potential GDA Issue 3 within our BAT assessment report to ensure that GNSL does this (Environment Agency, 2021c).

We requested further information with regard to identifying the major radionuclides, associated with the LLW and ILW. GNSL responded that the major radionuclides were identified using the principles set out within the Solid Radioactive Waste Management Technical User Source Term Report (GNSL, 2019c) and are those radionuclides that contribute greater than 10% to the total radioactivity. We are content that GNSL has addressed our query.

We also queried whether additional ILW would arise from the fuel management route for the UK HPR1000. GNSL's response provided us with confidence that no additional ILW would arise.

The Environment Agency is responsible for protecting groundwater, under the Environmental Permitting Regulations. We requested further information from GNSL, as to whether hazardous materials and non-hazardous pollutants were present within the inventory. GNSL has highlighted that carbon tetrachloride, chromium, antinomy, nickel, boron, and cadmium will be present. A future operator will need to ensure that its radioactive waste characterisation programme will take account of hazardous materials and non-hazardous pollutants.

Assessment Finding 14: A future operator shall ensure that its characterisation programme will identify any hazardous materials and non-hazardous pollutants that will be associated with the waste inventory for the UK HPR1000.

We requested additional information on the presence of complexants within the inventory. A complexant is a substance that readily forms complexes with specific molecules or ions, and these are of interest as it help us understand likely changes during long-term storage and after disposal. GNSL's response provided us with confidence that there are no significant concentrations of complexants within the inventory for the UK HPR1000.

From our findings within our initial assessment report, we requested that GNSL provides further information on the solid and non-aqueous inventory. GNSL has made significant progress in addressing our findings highlighted within the initial assessment report, and we are confident that by the end of GDA, GNSL will have addressed this finding.

Decommissioning wastes

Currently there are no reactors undergoing decommissioning in China but GNSL has developed a strategy and a plan for decommissioning the UK HPR1000 (GNSL, 2019a). GNSL has taken account of guidance from the International Atomic Energy Agency (IAEA) and other bodies as well as our regulatory guidance, legislation and national policy (IAEA, 2018, IAEA, 2016, IAEA, 2008, and Environment Agency, 2010). To determine the lead option for decommissioning the UK HPR1000, GNSL has carried out an optioneering exercise, which has identified immediate decommissioning as the preferred option for the UK HPR1000 (GNSL, 2019a).

GNSL has produced a Decommissioning Technical Source Term report, which provides information on the decommissioning wastes streams (GNSL, 2020g). The decommissioning wastes source term, comprises of the activated structure source term and the contamination source term. From the source term and the decommissioning plan which GNSL has developed for the UK HPR1000, GNSL has derived a waste management plan which provides an estimate of the inventory for the wastes arising from decommissioning the UK HPR1000.

The largest volume of solid wastes that will arise from decommissioning the reactor will be non-radioactive, and these materials will be able to be recycled and/or reused. The largest volumes of radioactive wastes, will be VLLW and LLW. Examples of these wastes are activated charcoal and building materials such as concrete and auxiliary piping. GNSL also states that a number of HAW streams will arise from decommissioning the UK HPR1000, such as reactor vessel internals (RVI), the reactor pressure vessel (RPV) and concrete from the bio-shield.

GNSL currently estimates that the volume of decommissioning radioactive solid waste for the UK HPR1000 will be approximately 12,279m^3.

Table 9-2 below summarises, at a high level, the solid wastes that will arise from decommissioning the UK HPR1000:

Table 9-2. The solid radioactive wastes from decommissioning a UK HPR1000

Waste type	Waste classification	Waste volume
Reactor pressure vessel	ILW	50m^3
Reactor vessel internals	ILW	18m^3
Spent resins	ILW	40m^3
Spent filter cartridges	ILW	1.4m^3
Concrete	ILW	150m^3
LAW arisings	LLW/VLLW	12,021m^3

A more detailed breakdown of the solid wastes is provided within the Decommissioning Waste Management Proposal (GNSL, 2020h). The major waste streams have been identified and are similar to those for other reactors, which have been assessed through the GDA process.

Our assessment of GNSL's waste management plan noted that the inventory was solely derived from the decommissioning of the reactor building. We queried whether any additional HAW would result from the decommissioning of other buildings on the nuclear island. GNSL's response provides us with confidence that no further HAW wastes will arise from the decommissioning of these buildings. It is important that a future operator periodically reviews this conclusion, and, if necessary, updates the decommissioning waste management plan or an equivalent document. This will be carried out as normal regulatory business.

We raised a Regulatory Query to seek further information on the waste classification of evaporators and to understand whether these will be replaced during the operational phase. GNSL clarified that the evaporators will be LLW and are not expected to need replacing.

We continue to assess whether the design of the UK HPR1000 has taken account of decommissioning. We do not expect this to impact on the decommissioning waste inventory significantly.

We are content with the approach that GNSL has used to derive the initial decommissioning inventory for the UK HPR1000. We will expect a future operator to continue to update this inventory, as more information becomes available during the operation of the reactor.

Spent fuel and non-fuel core components

Spent fuel (SF) is regarded as a waste within GDA, as currently there is no intention to reprocess the SF from new nuclear reactors. This is consistent with the UK government's policy for new nuclear reactors, as stated within the government white paper (BERR, 2008).

GNSL has decided to use the Framatome AFA 3GAA fuel. This fuel is a uranium dioxide pellet fuel, based on modern engineering standards. The fuel is clad in a zirconia based alloy that has good resistance to both corrosion and mechanical deformation. The fuel assembly consists of 264 fuel rods, arranged in a 17 x 17 array (GNSL 2020i). Within a number of assemblies gadolinia (gadolinium oxide) is used as a burnable poison. We requested additional information from GNSL to query the use of gadolinia and its impact on disposability. Based on the response from GNSL there is negligible impact. We are content with that response.

At equilibrium power generation, the fuel change for the reactor will be every 18 months, with typically 72 fuel assemblies being replaced every cycle. The burn-up for each fuel assembly is typically 47 gigawatt days per tonne of uranium (GWday/tU). The number of spent fuel assemblies that will be produced over a 60-year operational lifetime for the UK HPR1000 will be 2,985.

The non-fuel core components (NFCCs) that will arise from the UK HPR1000 are:

- rod cluster control assemblies (RCCAs)
- stationary core components assemblies (SCCAs)
- in-core instrument assemblies (ICIAs), of which there are 3 types (type (i), (ii) and (iii))

Further details of the NFCCs can be found is section 2 of the associated preliminary assessment report (Environment Agency. 2021e).

Typically, about 1,145 NFCCs will be produced over the lifetime of the reactor.

Currently a Regulatory Observation with regard to managing ICIAs is still open and this could alter the volumes of ICIAs that are classified as ILW and LLW. We have raised potential GDA Issue (GDAI-5) to ensure that the inventory is updated to take account of any changes.

Overall, we are content with the progress that GNSL has made with deriving an operational and decommissioning inventory for the UK HPR1000. We are confident that GNSL will be able to address any outstanding information by the end of GDA.

Minimising the quantity of solid waste

Minimising the solid radioactive waste at source and during the management of the solid waste are 2 important areas for ensuring that the amount of solid radioactive waste is minimised. Using BAT to minimise the activity in gaseous and aqueous discharges tends to transfer activity to solid waste. This is in line with the principle of preferred use of 'concentrate and contain' over 'dilute and disperse' (GB Parliament, 2009a). There is little opportunity to reduce the activity of this waste, except by decay storage when the waste contains radionuclides with short half-lives. However, the quantity (mass and volume) of waste requiring final disposal can be reduced by using techniques such as waste sorting and segregation, compaction, incineration, removal of surface contamination, re-use and recycling.

Information on the minimisation of solid waste arisings is provided in:

- Pre-Construction Environmental Report, Chapter 4 Radioactive Waste Management Arrangements, HPR/GDA/PCER/0004, Revision 001-1 October 2020 (GNSL, 2020a).
- Selection of Waste Containers for Disposal of ILW, GHX00100055DNFF03GN, Revision C, June 2020. (GNSL, 2020u).
- Optioneering Report for Operational Solid Waste Processing Techniques, GHX0010005DNFF03GN, Revision D, June 2020. (GNSL, 2020p).
- Pre-Construction Environmental Report, Chapter 5 Approach to Sampling and Monitoring, HPR/GDA/PCER/0005, Revision 001-1, October 2020. (GNSL, 2020i).
- Decontamination Processes and Techniques during Decommissioning, GHX71500010DNFF03GN, Revision C, June 2020. (GNSL, 2020o).
- Pre-Construction Safety Report, Chapter 21 Reactor Chemistry, HPR/GDA/PCER/0021, Revision 001, 2020. (GNSL, 2020l).
- Pre-Construction Environmental Report, Chapter 3 Demonstration of BAT, HPR/GDA/PCER/0003, Revision 001-1, October 2020. (GNSL, 2020j).
- Supportive Report of BAT on Nuclear Design, GHX00800007DRDG03GN, Revision D, January 2020. (GNSL, 2020k).
- Consistency Evaluation for Design of Facilitating Decommissioning, GHX71500005DNFF03GN, Revision D, June 2020. (GNSL, 2020m).
- Preliminary Decommissioning Plan, GHX71500004DNFF03GN, Revision E, November 2019. (GNSL, 2019a).

The following conclusion, with regard to minimising the quantity of solid and non-aqueous waste, was highlighted within our initial assessment report:

- GNSL to provide information on optimising solid waste disposal, including identifying boundary wastes

Our P&ID document (Environment Agency, 2016) and our REPs (Environment Agency, 2010) require GNSL to demonstrate that BAT has been applied and that the generation of wastes has either been prevented or minimised.

GNSL, via a series of claims, arguments and evidence has argued that the design and operation of the UK HPR1000 reactor will be optimised with regard to BAT and minimising radioactive wastes. Our review of these arguments and the supporting evidence will be discussed in greater detail within the BAT section of this consultation report and within our technical assessment report on BAT (Environment Agency 2021c). However, we provide a summary of how GNSL has applied BAT to minimise the production of solid wastes and deliver the waste management hierarchy and protect the environment. Delivering the waste management hierarchy means showing that waste is avoided and where waste is generated, the amount is minimised and that waste is reused and recycled where ever possible prior to disposal.

The amount of activity present and its behaviour within the primary circuit will have a significant influence on the production of solid radioactive waste. Therefore, minimising the activity in the primary circuit will lead to a reduction in the volume of solid wastes arising from the UK HPR1000. GNSL has made a series of arguments to support its sub-claim 4.1.EC03.1 Prevent and minimise the creation of radioactive waste (GNSL, 2020j), and sub-claim 4.1 EC03.4 Minimise the mass/volume of solid and non-aqueous wastes and spent fuel (GNSL, 2020j). We provide below a summary of the evidence that GNSL provides to support these claims.

Fuel design, manufacture and operation

As evidence to support its argument that the concentration of fission products in the primary coolant can be minimised by the design, manufacture and management of the fuel, GNSL states that the AFA 3GAA fuel is an advanced engineered fuel. Its design has taken account of several years of operational experience and therefore the risks from fuel failures, during operation of the reactor, have been minimised. We note that the fuel design has incorporated several new design features to minimise the risk of failures. Our assessment covered a number of supporting documents in relation to the new design changes and we are content that, in the majority of cases, the evidence presented by GNSL does demonstrate that the design changes to the fuel will minimise the arisings of spent fuel.

In addition to the design of the fuel, GNSL highlights a number of improvements to the manufacturing process. For example, using a water box and a blowing station to minimise the presence of zirconium chips on the external surfaces of the cladding. In addition, as part of the improvements to the manufacturing process, GNSL states that there have been improvements to the testing arrangements and quality assurance procedures to help reduce the potential for fuel failures (Framatome, 2019a).

The cladding on the AFA 3GAA fuel is highly resistant and has superior resistance to corrosion than other cladding materials (Framatome, 2019b).

ONR has raised a Regulatory Observation (RO-UKHPR1000-0015) which includes matters relating to the impact of crud on fuel failures. We will continue to engage with ONR and GNSL in relation to the impact that this may have on minimising fuel arisings.

As evidence to support the argument that the concentration of fission products can be minimised by detecting and managing failed fuel, GNSL has demonstrated that the UK HPR1000 will have the capability to detect failed fuel during operation and during refuelling of the reactor core. The early detection of failed fuel will lead to a reduction in the amount of solid wastes that will be produced (GNSL 2020j).

As evidence, to support its argument that the quantity of spent fuel arisings will be minimised, GNSL has assessed the impact of the core dimensions and cycle length on the quantity of fuel that will be used. It has demonstrated that the amount of fuel used per unit of power production is less for the UK HPR1000 than an equivalent Chinese reactor, such as the CPR1000, as a result of the changes to the core dimensions. GNSL has identified an 18-month equilibrium fuel cycle as the optimum for the UK HPR1000 (GNSL 2020k). However, a future operator may decide to use a different fuel length cycle and therefore we have raised Assessment Finding 11 within our BAT assessment report (Environment Agency 2021c).

We have assessed the evidence that GNSL has provided in order for it to demonstrate that the modifications to the fuel design, manufacturing processes, the detection of failed fuel and the core dimensions and fuel cycle is optimised and will lead to the minimising of solid wastes. We are content at this stage of GDA from an environmental perspective, however we will assess the outputs from RO-UKHPR1000-0015 and any future reports on the improvements to the fuel design before the end of GDA.

Corrosion control (Chemistry)

GNSL argues that control of the primary coolant chemistry is crucial in minimising the generation of solid radioactive waste across the life cycle of the reactor (GNSL 2020j). Controlling the chemistry of the coolant will minimise the generation of corrosion and activation products, as well as minimising the production of waste from the maintenance of the structures systems and components (SSCs). The main controls on the coolant properties are (GNSL 2020l):

- pH
- hydrogen concentration
- hydrazine (added at start up, to scavenge for oxygen)
- other impurities
- zinc concentration

ONR has raised a number of Regulatory Queries with regard to the primary circuit chemistry. GNSL's responses to these queries has led to an update of the 'Demonstration of BAT' document, but this has had no impact on our preliminary conclusions. A Regulatory Observation has also been raised to query the approach to boron control in the primary coolant during normal operations and fault conditions. The outcome of this Regulatory Observation is unlikely to impact on our primary conclusions. We will continue to monitor this observation as part of our ongoing assessment.

Corrosion control (Material selection)

In addition to controlling the water chemistry, GNSL argues that the choice of material for the structures, systems and components (SSCs) of the UK HPR1000 is important in minimising the quantity of solid waste that will be produced (GNSL 2020j). GNSL has provided a number of examples to demonstrate how changes made to the materials used in the construction of the UK HPR1000 will lead to a reduction in the quantity of solid wastes. For example, reducing the use of silver (Ag) coated seal gaskets within the primary circuit will, in turn, reduce the concentration of Ag-110m within the primary coolant.

GNSL proposes to use corrosion resistant materials for constructing SSCs in the primary circuit. This will lead to a reduction in the concentration of corrosion products that will circulate within the primary coolant and deposit on other surfaces.

Building layout

GNSL proposes to use radiation and contamination zoning within the UK HPR1000 buildings, and to optimise the layout of these buildings to minimise the volume of structures, systems and components that will become radioactive waste. For example, by keeping the areas such as the operator control room outside the controlled areas, the amount of waste can be minimised. In addition, by keeping buildings close to each other, this will lead to a reduction in the quantity of solid wastes, particularly at the decommissioning phase of the plant's life cycle.

GNSL has demonstrated that it has rationalised the number of SSCs within the design for the UK HPR1000 compared with the previous reactor design (the CPR1000). An example of this is removing a non-regenerative heat exchanger from the chemical volume and treatment system, therefore leaving only the regenerative heat exchanger needing disposal (GNSL, 2020j).

We are supportive of the approaches that GNSL highlights above to minimise the quantity and activity of the solid waste arisings from the UK HPR1000 with respect to BAT.

Maintenance and life cycle

GNSL has provided evidence, to support its argument, that it has optimised the lifetime of a number of components within the primary circuit and the auxiliary circuits. Therefore, a future operator will not need to replace these components as often. For example, for a number of the auxiliary systems the demineralisers and filters that will be used for the UK

HPR1000 are more efficient than those used on the CPR1000 reactors and will be protected by high temperature and pressure cut offs (GNSL, 2020j).

In addition, GNSL has highlighted that within the reactor the tools and equipment that will be used for maintenance operations will be kept within the controlled area and will be re-used whenever possible.

Decommissioning

The claims, arguments and evidence presented by GNSL apply equally to both operational and decommissioning wastes. The vast majority of the decommissioning wastes that will arise from the UK HPR1000 will be solid wastes, with only a small fraction being gases or liquids (which are out of scope of GDA).

GNSL has evaluated the reactor design in order to demonstrate that the design has taken account of decommissioning, and, where possible, will prevent or minimise wastes (GNSL, 2020m). It will do this, for example, by considering material selection, design layout, the control of activation and waste management.

At the time of writing, we are content that GNSL has provided a reasonable overview of how the design of the UK HPR1000 has taken account of decommissioning and will lead to a reduction in the quantity of solid wastes. However, we will continue to assess this area as part of our ongoing assessment.

During decommissioning, a future operator will need to ensure that the generation of secondary wastes from activities such as decontamination and dismantling will be minimised. Decontamination can play an important role in reducing the quantity of solid wastes or can change the categorisation of the wastes. GNSL has made best use of the OPEX available internationally to understand how decontamination could be applied to the UK HPR1000 (GNSL, 2020n and 2020o). GNSL states that periodic decontamination, during the operational phase, of the primary and auxiliary circuits, could reduce the volumes of solid waste. However, this will be a decision for a future operator to make. We will expect a future operator to assess this opportunity and have raised the following Assessment Finding to ensure this takes place:

Assessment Finding 15: A future operator shall assess whether there are benefits in periodic decontamination of the UK HPR1000 primary circuit and its related systems and auxiliary circuits with regard to minimising production of decommissioning wastes and their classification. The future operator should demonstrate that BAT is being applied.

We note that before dismantling the reactor, GNSL proposes to decontaminate the primary circuit. GNSL has chosen CORD D UV as the preferred decontaminating agent (GNSL 2020o). We queried why this agent had been chosen, noting that other decontamination agents, could perform better. GNSL responded by highlighting the advantages and disadvantages for each of the decontamination agents. It was evident from the information provided that the advantages in using CORD D UV outweighed those of the other agents. In addition, GNSL provided additional OPEX where CORD D UV has been used at a nuclear power station in Germany to decontaminate the SSCs. We are content with the evidence GNSL provided to support its decision, however the final decision will be for a future operator to take.

Over the lifetime of the reactor, we acknowledge that the techniques for decontaminating and dismantling the UK HPR1000 reactor will improve. There will also be extensive international experience available from the decommissioning of a number of PWRs from around the world, as they reach the end of their lifetime. A future operator will continue to develop the decommissioning plan for the UK HPR1000 over its operational period, and we will expect the operator to make best use of the international experience available to ensure that BAT is being applied. We have raised the following Assessment Finding to ensure that a future operator does so:

Assessment Finding 16: A future operator shall ensure that the decommissioning plan is periodically reviewed to ensure that BAT is being applied with regard to decommissioning the UK HPR1000.

Our preliminary conclusion is that GNSL has made good progress in demonstrating that the waste generated at source has been minimised. However, we have highlighted a number of Assessment Findings that will need to be addressed, to ensure that the design of the UK HPR1000 will meet with our expectations with regard to BAT.

Management of solid and non-aqueous wastes

The regulatory regimes in China and the UK are different and therefore it was noted, at an early stage in the GDA process, that there may be differences in the approaches to managing solid and non-aqueous radioactive wastes. A Regulatory Observation and several Regulatory Queries were raised to question what gaps exist between the different approaches for managing the radioactive wastes that will arise from the UK HPR1000. GNSL's response indicated the following gaps:

- treatment of ion exchange resins
- dry active waste segregation and treatment process
- oils and organic solvents treatment process
- low activity spent resins and ventilation filter cartridges management process
- management of RCCAs, SCCAs and ICIAs
- ILW waste shielding container
- ILW/LLW waste storage areas

To address the above gaps for managing solid wastes, GNSL carried out an optioneering exercise to identify the preferred options for treating solid and non-aqueous waste (GNSL, 2020p). A similar exercise was also carried out for managing the NFCCs (GNSL, 2019e). We will discuss the NFCC optioneering exercise later in this chapter.

Management and disposal of lower activity wastes

Lower activity wastes (LAW) can currently be disposed of in the UK. Possible disposal routes include transfer to the Low Level Waste Repository (LLWR) in Cumbria, transfer to landfill sites that are permitted to receive radioactive waste, on or off-site incineration, and transfer off-site for recovery (for example, of metals).

Information on the disposal of LAW was supplied within the following documents of GNSL's submission:

- UK HPR1000 Waste Enquiry Form, GHX00100036DNFF03GN, Revision C, November 2019. (GNSL, 2019g)
- Pre-Construction Environmental Report, Chapter 4 Radioactive Waste Management Arrangements, HPR/GDA/PCER/0004, Revision 001-1 October 2020. (GNSL, 2020d)
- Response to LLWR Agreement in Principle, GHX00100099DNFF03GN, Revision B, June 2020. (GNSL, 2020q)
- Letter Re: Disposability in Principle Assessment for UK HPR1000, GNSL Ref: GHX00100036DNFF03GN, January 2020. (GNSL, 2020z)

The following findings were highlighted within our initial assessment report. GNSL was to:

- provide information on optimising solid waste disposal, including identifying boundary wastes
- provide information on engaging with waste disposal operators about disposability of wastes and spent fuel

LAW comprises solid wastes with a waste classification of LLW or VLLW. LLW are those wastes, where the radioactivity content is equal to or less than 20giga-bequerels per tonne (GBq/tonne) beta/gamma and 4bequerels per tonne (Bq/tonne) alpha. VLLW is a sub-class of LLW. For this GDA, the UK's LLW repository in Cumbria is the preferred location for the treatment and final disposal of all LAW that arises from the UK HPR1000 reactor. However, we will expect a future operator to take account of the proximity principle and the waste management hierarchy when deciding on the best location to treat or dispose of its LAW. We raised Assessment Finding 2 to ensure that this takes place (Environment Agency 2021b).

Our P&ID document requires GNSL to demonstrate that LAW (VLLW and LLW) arisings from the UK HPR1000 can be treated and disposed of via the routes available within the UK (Environment Agency, 2016).

As part of the design of the UK HPR1000, GNSL highlights that the waste auxiliary building will be the primary building for segregating, treating and conditioning LAW on a site. GNSL will be providing further information in relation to the design and layout of the waste auxiliary building within the report 'Conceptual Proposal of Waste Auxiliary Building', which we will assess as part of our ongoing assessment. However, we note that this building design is currently out of scope for GDA.

GNSL highlights a number of examples to demonstrate that LLW can be segregated, and that the quantity of waste that will be disposed of will be minimised. For example, by using different processing tanks within the solid waste treatment system, the steam generator blowdown system (SGBS) LLW resins can be kept separate from the processing of the ILW resins. A further example is where GNSL proposes to segregate the dry active wastes arising from the UK HPR1000 into wastes requiring metal melting, incineration, compaction or disposal.

We note that for the treatment of LLW sludges and concentrates, GNSL proposes to encapsulate the LAW wastes. We have raised a Regulatory Query to challenge why GNSL has identified this approach as the lead technology for these wastes. The Regulatory Query remains open and we will assess GNSL's response as part of our ongoing assessment, as this could impact on the disposal inventory.

GNSL has proposed the following off-site treatment and disposal options for the LAW arisings from the UK HPR1000 (Table 9-3).

Table 9-3. Off-site treatment and disposal options for the LAW arisings from the UK HPR1000

Waste type	Treatment/disposal option
LLW resins	Package in 210L drum and sent off site for incineration.
LLW ventilation filter	Packaged within a bag and sent for super-compaction and then disposal at the LLW repository.

Waste type	Treatment/disposal option
LLW concentrates	Encapsulation in grout within a 210L drum and disposed of at the LLW repository.
LLW sludges	Encapsulation in grout within a 210L drum and disposed of at the LLW repository.
Oils	Packaged in a 210L drum on-site and sent off-site for incineration.
Solvents	Packaged in a 210L drum on-site and sent off-site for incineration.
Spent filters	Packaged in a 210L drum for off-site super-compaction and disposed of to the LLW repository.
Dry active waste - metals	Packaged in a metallic box and then sent off-site for metal melting.
Dry active waste - compactible	Pre-compaction in a 210L drum and the sent off-site for compaction.
Dry active waste - combustible	Pre-compaction in a 210L drum and then sent off-site for incineration.
Dry active waste - non-compactable/non-combustible	Packaged in a 210L drum and then encapsulated in grout off-site for disposal to the LLW repository.

In addition to the above wastes, GNSL proposes to consign a number of ILW/LLW boundary wastes to the LLW repository. We discuss our assessment of this approach within our assessment report AR05 (Environment Agency, 2021e).

GNSL makes the claim that it will select the optimal disposal routes for the wastes. As evidence, in support of this claim, GNSL has sought an agreement in principle from LLWR Ltd with regard to its plans for conditioning and disposing of the LAW arisings from the UK HPR1000. LLWR Ltd's assessment of GNSL's proposals indicates that the wastes are likely to be acceptable. However, it has raised a number of queries, where additional information will be required from a future operator (LLWR, 2020a).

In response to LLWR Ltd's agreement in principle, GNSL has carried out a preliminary assessment of the points raised by LLWR Ltd, to demonstrate that a future operator should be able to address these points (GNSL, 2020q). It has split its response into 2 categories, one being normal business issues and the second being specific issues/constraints. Ten normal business issues were raised and 4 specific issues/constraints, which we have assessed, and are content that a future operator should be able to address these issues, nearer the time for disposal.

The disposal of LLW from decommissioning is out of scope, and it will be for a future operator to demonstrate that the disposal of these wastes will be BAT and will meet with the disposal facilities' waste acceptance criteria (WAC).

GNSL has made good progress in addressing the initial assessment findings. However, we have requested further information regarding its proposed option for treating LLW concentrates and sludges to demonstrate that BAT is being applied. We are content that the LAW will be disposable, however a future operator will need to demonstrate that the lead options, chosen by GNSL, will still be BAT at the time of disposal. We have written an assessment finding to ensure that this is the case:

Assessment Finding 17: A future operator shall review periodically the options for the treatment and disposal of solid low level waste from the operation and decommissioning of the UK HPR1000. The future operator shall ensure that the options implemented are BAT and will meet the disposal facilities waste acceptance criteria.

Management and disposability of higher activity waste and spent fuel

Higher activity wastes currently have no disposal route in the UK. It is government policy that these, along with spent fuel, will be disposed of to a geological disposal facility (GDF) that the government intends to construct (DECC, 2011). In the meantime, they need to be managed in a way that adequately protects people and the environment, without compromising their disposability in a future GDF.

Information on managing and disposing of higher activity wastes and spent fuel can be found in the following documents of GNSL's submission:

- Pre-Construction Environmental Report, Chapter 4 Radioactive Waste Management Arrangements, HPR/GDA/PCER/0004, Revision 001-1 October 2020. (GNSL, 2020d).
- Management Proposal of Waste Non-Fuel Core Components, GHX00100064DNFF03GN, Revision D, November 2019. (GNSL, 2019e).
- Conceptual Proposal of ILW Interim Storage Facility, GHX00100063DNFF03GN, Revision C, December 2019. (GNSL, 2019f)
- Technology Optioneering on Spent Fuel Interim Storage, GHX0100057DNFF03GN, Revision B, March 2019. (GNSL, 2019h)
- Radioactive Waste Management Case for ILW, GHX00100066DNFF03GN, Revision C, April 2020. (GNSL, 2020r).
- Radioactive Waste Management Case for HLW, GHX00100065DNFF03GN, Revision C, April 2020. (GNSL, 2020s).
- Spent Fuel Interim Storage Facility Design, GHX00100081DNFF03GN, Revision D, April 2020. (GNSL, 2020w).
- UK HPR1000 HAW Disposability Assessment Submission, GHX00100035DNFF03GN, Revision D, June 2020. (GNSL, 2020y).
- Higher Activity Waste and Spent Fuel Disposability Assessment Deliver Strategy, HPR-GDA-REPO-0150, June 2020. (GNSL, 2020aa).
- UK HPR1000 HAW and SF Disposability Assessment End of June 2020 Status, HPR-GDA-REPO-015, June 2020. (GNSL, 2020x).
- Pre-Construction Safety Case, Chapter 29, HPR/GDA/PCSR/0029, Revision 001, January 2020. (GNSL, 2020v).

The following Assessment Findings, with regard to managing and disposing of higher activity wastes and spent fuel was highlighted within our initial assessment report. GNSL is required to provide:

- information on the options selection and arrangements for interim storage of solid wastes
- information on optimising solid waste disposal, including identifying boundary wastes

- information on engaging with waste disposal operators about disposability of wastes and spent fuel
- quantification of the likely solid waste and spent fuel disposals
- information on the proposed conditioning and packaging of spent fuel

Our expectations with regard to managing higher activity waste (HAW) are highlighted within the Joint Guidance on the Management of HAW (Environment Agency and others, 2015). An important requirement of the joint guidance is for a licensee to produce a radioactive waste management case (RWMC). An RWMC provides various stakeholders with an overview of how a site licensee plans to manage its HAW and achieve the main elements of long-term safety and environmental protection.

GNSL has produced 2 RWMCs, one detailing the arrangements for managing the ILW arisings from the UK HPR1000 (GNSL, 2020r), while the second provides the arrangements for managing the HLW arisings (GNSL, 2020s). However, as GNSL progresses with its submission for GDA, there will be a requirement for these documents to be updated, in particular with regards to the disposability of the HAW. We will continue to review the RWMCs as we make progress with our assessment. However, we see no reason why GNSL, by the end of GDA, cannot have in place RWMCs that meet with our expectations, for this stage in the new build process. A future operator should continue to update the RWMCs, and we have raised an Assessment Finding to ensure that this is the case:

Assessment Finding 18: A future operator shall periodically update the Radioactive Waste Management Case or equivalent documentation in accordance with the Environment Agency's and ONR's joint guidance, in order to demonstrate that the higher activity waste is being managed across the whole life cycle.

For the UK HPR1000, GNSL plans to process the operational HAW solids through the solid waste treatment system (SWTS). Within the SWTS, the solid wastes will be characterised, segregated, conditioned and stored (GNSL, 2020d). The operations performed by the SWTS occur within a number of buildings. Ion exchange resins, spent filters, sludges, concentrates and ILW dry active wastes will be processed through the SWTS. ICIAs will also be processed via this route, however we will discuss this later in this chapter. Decommissioning wastes with similar characteristics to the operational solid wastes are also likely to be processed through the SWTS. We describe in greater detail, within the following sections, GNSL's proposals for managing the HAW arisings from the UK HPR1000, across the life cycle.

Characterisation and segregation

To meet our expectations, it is essential that GNSL can demonstrate that characterisation and segregation of the wastes is possible for the UK HPR1000. GNSL has provided an overview of the processes and locations for sampling solid radioactive wastes for the UK HPR1000 (GNSL, 2020t). GNSL provided further supporting information within the solid waste treatment system design manuals.

Grab sampling is one of the primary techniques that will be used within the UK HPR1000 for sampling solid HAWs, such as ion exchange resins, condensates and sludges. Subsequent characterisation of these solids within a laboratory will provide the relevant information required for disposing of the wastes.

In addition to grab sampling, GNSL will also use dose measurements and scaling factors as methods to characterise the solid wastes, such as for spent filters and ILW dry active wastes.

This information gives us confidence that the sampling of the solid wastes will be feasible for the UK HPR1000. However, we have written an Assessment Finding to ensure that a future operator will further develop its characterisation strategy and sampling approach for solid wastes within the detailed design stage, to ensure that the approach will be BAT.

Assessment Finding 19: A future operator shall develop its characterisation strategy and approach to segregation for solid and non-aqueous wastes further at the detailed design stage, to ensure that it can demonstrate that BAT is being applied.

Within the PCER Chapter 3 Demonstration of BAT, GNSL argues that to reduce the mass/volume of solid waste that needs disposal, efficient segregation should be deployed (GNSL, 2020j).

Segregating the UK HPR1000 HAW wastes will be achieved by separating the different classifications of wastes when they are generated or by processing them via different routes, which have been incorporated into the design of the UK HPR1000. GNSL provides several examples, such as:

– the different treatment routes for ILW resins and LLW SGBS resins
– the different treatment routes for HAW sludges and concentrates from LLW sludges and concentrates
– the segregation of ILW dry active wastes at source from the LLW dry active wastes

We are confident that the design of the UK HPR1000 and the approach to sampling and characterisation will allow the future operator to perform effective characterisation and segregation of the solid wastes.

GNSL acknowledges the importance of characterisation and segregation in minimising the volume of radioactive waste that will arise during decommissioning and in maximising the amount of solid waste that can be recycled or reused. GNSL's decommissioning plan highlights that a future operator will carry out a full characterisation survey of the UK HPR1000 reactor and licensed site before decommissioning. This will allow a future operator to better define its waste management strategy for decommissioning wastes and its decommissioning plan (GNSL, 2019a).

GNSL has made best use of the OPEX available to identify the technologies that could be used today to decommission the UK HPR1000. This OPEX provides further evidence to demonstrate that a future operator could segregate the solid wastes during decommissioning. For example, by using scabbling technologies to remove the highly active surface concrete layer, a future operator can minimise the volume of concrete that will be disposed of to a GDF.

We are content that GNSL has demonstrated the importance of characterisation and segregation. It has also demonstrated that the UK HPR1000 will have the capabilities to ensure that the wastes can be characterised and segregated.

Conditioning and packaging

GNSL has carried out an optioneering exercise to identify the preferred options for conditioning the HAW arisings from the UK HPR1000 (GNSL, 2020p). It has also carried out an optioneering exercise to identify the preferred containers for packaging the ILW arisings. (GNSL, 2020u).

GNSL has selected dewatering of the ion exchange resins within a 500L robust shielded container as its preferred option for processing HAW ion exchange resins. The resins will be dried, so that the residual water content within a container will be less than 1%. This approach has been previously used at Sizewell B and several Magnox stations, as well as internationally. We are content that GNSL's approach to packaging and conditioning of the HAW resins is likely to lead to a disposable product.

GNSL has identified its preferred option for conditioning and packaging the spent filters as grout encapsulation within a $3m^3$ box. GNSL has demonstrated, via the packaging optioneering study, that using a $3m^3$ box will allow the disposal of the maximum number of filters per package. We are content with the proposed approach for the conditioning and packaging of the spent filters.

For a number of ILW streams, GNSL has identified a number of potential boundary wastes that could be decay stored to become LLW. GNSL identified ILW concentrates, sludges and dry active waste as potential boundary wastes. We see decay storage as an effective method for managing the HAW and for optimising the disposal routes for the wastes.

ILW dry active wastes will be identified when they are generated and will be packaged in a shielded 210L drum before being transferred to the ILW interim store for decay storage. It will take approximately 2 years for these wastes to decay (GNSL, 2020d). Once decayed, the wastes will be transferred to the auxiliary building and will subsequently follow the same waste management routes as those identified for LLW dry active wastes.

GNSL proposes to decay store ILW concentrates and sludges. GNSL's preferred strategy is to encapsulate these wastes. The encapsulated 210L drums will then be transferred to the ILW interim store to decay. The sludges and concentrates will decay to LLW in approximately 16.5 and 7.5 years respectively. We raised a Regulatory Query to request further information on whether the average or maximum activities of these wastes were used to determine the decay periods. GNSL's response stated that the maximum activity values were used and that this will provide a degree of conservatism with regard to the decay times. We are content with GNSL's response.

We note that if the ILW encapsulated sludges and concentrates did not decay to LLW, then these drums will have to be disposed of to a GDF. The 210L drum is not an acceptable package for a UK GDF based on RWM's current waste package specifications. Therefore, a future operator would need to engage with RWM to determine if it was possible to entomb the 210L drums within a package compliant with a UK GDF.

GNSL has sought advice from RWM with regard to the disposal of encapsulated ILW sludges and concentrates within a 500L drum. A future operator will therefore have an alternative strategy that it can implement if it decides that the decay strategy is not plausible. However, we will expect a future operator to demonstrate that BAT is still being applied if these wastes are diverted to a GDF.

We are content, at the time of writing this report, that GNSL has demonstrated 2 likely options for disposing of the concentrates and sludges. However, it will be for a future operator to determine the final strategy for managing these wastes. ONR are continuing to assess this area as part of their ongoing assessment which may impact on our conclusions.

GNSL has identified the preferred options for conditioning and packaging the ILW wastes that will arise from decommissioning the UK HPR1000 (GNSL, 2020h). The preferred options are for the reactor pressure vessel (RPV) to be grouted within a 4m box (due to better packing efficiency), the reactor vessel internals (RVIs) to be grouted in a $3m^3$ box, and the activated concrete to be grouted in a 4m box. Ion exchange resins and spent filters are to be conditioned and packaged using the same processes as for the same wastes produced during the operational period.

GNSL claimed that there is the potential for ILW/LLW boundary ion exchange resins to be generated during decommissioning. GNSL plans to grout these resins and decay store the resins until they are LLW. We raised a Regulatory Query to question this approach, as we questioned whether this would be BAT. GNSL responded that the resins will need to be stored in a passively safe form, while being decay stored to LLW and therefore will need to be grouted. We will expect a future operator to demonstrate that the approach for managing the boundary resins will be BAT nearer the time of disposal.

GNSL has proposed that the RPV is segmented into a number of sections and subsequently grouted in a 4m box. Our assessment noted that within one 4m container only 15% of the volume of the container will be taken up by the waste. We requested further information from GNSL as to whether other RWM compliant waste packages would result in a better packaging efficiency for the wastes. GNSL's response argued that the number of cuts should be minimised due to ALARP considerations (an ONR nuclear safety requirement), and therefore the 4m box provided the best option for this waste stream. However, we agreed with GNSL that a future operator will need to assess whether other containers offer a better balance between ALARP and BAT nearer the time of disposal. We are content that GNSL has demonstrated that the wastes can be disposed of.

We are content that the preferred options chosen by GNSL will likely lead to a disposable product. However, we note that, in a few cases, a future operator will need to demonstrate that the options chosen will be BAT, especially for the decommissioning wastes.

Assessment Finding 20: A future operator shall ensure that the proposed conditioning and packaging options for the higher activity wastes for the operational and decommissioning waste arisings from the UK HPR1000 are BAT.

Interim storage of ILW

ONR is the lead regulator for the accumulation of wastes on a nuclear licensed site. However, our REPs, principles RSMDP 10 and 11, indicate that operators should be able to demonstrate that the conditions of the actual store and the packages within it will be maintained (Environment Agency, 2010). Our REPs also indicate that the packages should be able to be monitored and inspected during the storage period to ensure that they remain disposable in the future. GNSL has used UK and international guidance to develop its conceptual design for storing ILW. GNSL has carried out a series of optioneering exercises to identify the preferred design of the store, the arrangement of the packages within it, and for the type of storage that will be used, such as vault versus shaft. A future operator will provide further information at the detailed design stage.

GNSL argues that the 2-phase approach in constructing the stores will ensure that a future operator can make best use of the learning from the operation and design of the first. This approach appears reasonable in ensuring that BAT is applied at all times across the lifetime of the stores. However, ONR has requested further information via a Regulatory Observation with regard to the safety justification for this 2-phased approach. We will take into account the response to this Regulatory Observation with regard to the 2-phase construction and whether there are any implications for BAT and the disposal of solids wastes.

We questioned how the phased construction of the stores will take into account the rate of arisings of the wastes into the first store. GNSL states that a future operator will assess this parameter when determining when to begin construction of the second store.

GNSL has proposed that the first phase of the ILW interim store will accommodate the solid radioactive waste arisings from the first 30 years of operation of 2 UK HPR1000 reactor units. However, ONR noted that this does not taken into account any waste from accidents or any foreseeable incidents. It was also noted that GNSL stated a contingency with regard to the storage capacity for the interim stores, but did not substantiate this. Further information was requested from GNSL with regard to the capacity of the stores. We expect that all wastes can be stored under the appropriate conditions to ensure that they will be disposable. We have an interest in the response from GNSL and will continue to monitor the outcomes of the Regulatory Observation as part of our ongoing assessment.

GNSL indicates that there will be different storage locations for shielded containers, unshielded drums and $3m^3$ unshielded boxes. GNSL proposes to store the packages in a vertical array and within storage vaults. ONR has requested further information with regard to the design of the store and how the available OPEX has been used to attain the conceptual design.

GNSL proposes that the packages will be inspected in-situ, using a camera attached to the vault crane. The vertical stacking array will help this form of inspection. GNSL also proposes to have a maintenance area within the store, which will allow packages to be inspected in greater detail and any maintenance of the packages to be carried out. However, there is limited information with regard to the inspection of the store itself. A Regulatory Observation was raised to request further information on the monitoring and inspection of packages and of the store. This would ensure that people and the environment would continue to be protected. We will expect GNSL to provide this information before the end of GDA.

GNSL states that within the store that there will be a holding area for packages which either are or have become non-compliant during the storage period. We note that a future operator will need to develop its arrangements for identifying and managing these non-compliant packages within the store and to ensure that they will be disposable in the future.

Assessment Finding 21: A future operator shall develop arrangements for identifying and managing non-compliant waste packages, to ensure that only packages that are suitable for disposal will be transferred to a GDF.

Decommissioning wastes will be placed within the second phase of the ILW interim store. Therefore, a future operator will need to ensure that BAT is applied to the design of the second phase of the ILW interim store.

Our preliminary conclusion is that if the Regulatory Observations are addressed, there is no reason why the proposed conceptual design will not produce a store which will apply BAT and will ensure that the packages remain disposable in the future. ONR's assessment may result in changes to the design and operation of the store and therefore we will continue to engage with ONR as we continue with our assessment.

Management of spent fuel and non-fuel core components

Spent fuel

We expect GNSL to demonstrate that it has a credible strategy for managing spent fuel and that BAT will be applied to achieve this. We provided GNSL, through a joint letter with

ONR, with our expectations for GDA regarding the management of spent fuel (Environment Agency and Office for Nuclear Regulation, 2018).

GNSL's fuel management strategy requires the spent fuel assemblies (SFA) to be stored within the spent fuel pool for a short period, typically between 5 and 10 years, followed by interim storage for a period of at least 100 years. It is proposed that a future operator will begin transferring the SFAs to a GDF in 2130 (GNSL, 2020d).

GNSL has carried out an optioneering exercise to identify the preferred option for the interim storage of the SFAs (GNSL, 2019f). Two options were assessed in detail, one being wet storage of the spent fuel within a pool, while the second was dry storage within a metal canister/concrete silo arrangement. GNSL identified the dry storage within a metal canister/concrete silo arrangement as the preferred option for the interim storage of spent fuel for the UK HPR1000. A future operator may decide to use a different approach to managing the spent fuel, however it will be expected to demonstrate that the approach will be BAT.

In order for the SFAs to be transferred from the spent fuel pool to the SFIS, the fuel must be dried. Drying the fuel, before transferring it to the SFIS, involves vacuum drying the assemblies, followed by purging the spent fuel/canister arrangement with an inert gas, such as helium. We requested further information from GNSL on what level of dryness is required before the SFAs can be transferred to the SFIS. GNSL responded by stating that the degree of dryness depends on the canister design chosen. Currently this is acceptable for GDA as we agreed that specific suppliers/vendors do not need to be identified at this stage. We will expect a future operator to demonstrate that BAT is being applied during the drying process. We have raised the following Assessment Finding to ensure that this is the case:

Assessment Finding 22: A future operator shall ensure that it deploys BAT for the conditioning of the spent fuel, prior to transferring the spent fuel assemblies to the spent fuel interim store.

The SFIS design is at the conceptual level and will be further developed by a future operator at the detailed design stage. GNSL proposes to construct the SFIS in 2 phases, with the first phase accommodating the spent fuel, HLW ICIA arisings from the first 30 years of operation of 2 UK HPR1000 reactors (GNSL, 2020v and 2020w). The second phase will accommodate the arisings from the next 30 years of operation. This approach will allow a future operator to take account of any learning and technical developments to ensure that BAT will be applied across the lifetime of the stores.

We expect GNSL to be able to demonstrate that the requirements for the long-term storage of the spent fuel from the UK HPR1000 can be achieved by the SFIS design and will minimise the risk of fuel clad failures during storage. The design of the SFIS has been based on publicly available information and international and UK OPEX. GNSL sees the proposed conceptual design as a bounding case for the storage of the spent fuel, as the properties of the spent AFA 3GAA fuel are typical of the fuels that are dry stored around the world. Therefore, it is envisaged that the properties and operating parameters proposed for the conceptual design can meet the long-term requirements for the storage of the AFA 3GAA fuel. However, currently GNSL has not provided the specific information in relation to the requirements for the long-term storage of the AFA 3GAA fuel. GNSL will provide this information for assessment before the end of the GDA process.

Potential GDA Issue 4: GNSL is required to provide information in relation to the long-term storage requirements for the spent fuel and to demonstrate that the conceptual design for spent fuel interim store (SFIS) will deliver these requirements.

We requested further information with regard to the monitoring and inspection of the fuel/canister arrangement within the SFIS. GNSL proposes to measure the temperature of the air being used to passively cool the canister, to verify that the canister and fuel are performing as expected. We sought further information on this process and whether other inspection methods such as visual inspection could be used. GNSL provided further information on the process it proposes for monitoring the integrity of the fuel and canister. The response from GNSL also provided us with confidence that other monitoring and inspection techniques could be used to assess the integrity of the canister. However, this depends on the chosen design for the canister/silo arrangement and will be a decision for a future operator to make. We will expect a future operator to demonstrate that BAT is being applied with regard to the inspection and monitoring of the fuel and canister during the storage period. We have raised the following Assessment Finding to ensure that this is the case:

Assessment Finding 23: A future operator shall ensure that the monitoring and inspection of the spent fuel assemblies and canister, within the spent fuel interim store are BAT.

We note that for the AFA 3GAA fuel, GNSL states that the expected number of fuel failures that will occur will be low. We requested additional information with regard to managing failed fuel, in particular managing it within the spent fuel pool and the potential to transfer the failed fuel assemblies from the pool to the dry store. GNSL provided additional information on managing failed fuel within the pool and highlighted that the current strategy is to store the failed fuel assemblies within the pool until decommissioning of the spent fuel pool. We were content with the reply and that this approach will not rule out any options for disposing of the fuel. However, a future operator will need to demonstrate that the current strategy for storing failed fuel will be BAT.

Assessment Finding 24: A future operator shall ensure that the strategy for managing failed fuel over the life time of the UK HPR1000 is BAT.

We challenged GNSL as to whether the storage of failed fuels would generate additional wastes during the storage period. However, GNSL has stated that no additional wastes will be generated.

We asked GNSL whether the disposability assessment that RWM will carry out will take account of the disposal of failed fuel assemblies. GNSL's response stated that it wouldn’t. However, we note that the assessment of intact spent fuel assemblies is likely to bound the disposal of the failed fuel to a GDF.

Our preliminary conclusion is that if GNSL can address the potential GDA Issue and the Assessment Findings are addressed in future, there is no reason why the conceptual design cannot lead to a store that is capable of storing the spent fuel assemblies for the long term in accordance with BAT, and that the assemblies will be disposable in the future to a GDF. We note that ONR will assess the store design from a safety and operational perspective.

Non-fuel core components

The non-fuel core components (NFCCs) have been described above. To identify the preferred option for managing the RCCAs, SCCAs and ICIAs, GNSL carried out an optioneering exercise (GNSL, 2019e).

The preferred option chosen for managing the RCCAs and SCCAs was to co-store them as an integral part of the spent fuel assembly, both during storage within the spent fuel pool and for longer term storage within the SFIS.

Further information was requested from GNSL with regard to the characterisation of the RCCAs and SCCAs. GNSL responded by stating that the RCCAs and SCCAs are not characterised, but theoretical calculations have been carried out to determine the activity of the wastes.

Further information was requested from GNSL as to whether there would be enough spent fuel assemblies within the pool, during refuelling to accommodate the spent RCCAs and SCCAs. GNSL's response highlighted that there would be and, therefore, co-storage of the RCCAs and SCCAs within the pond should not present a challenge to a future operator.

Further information was requested from GNSL in relation to the integrity of the RCCAs and SCCAs during storage within the spent fuel pool. GNSL's response states that there is no risk of degradation during the storage within the pool, as the chemistry of the pool water is controlled and therefore will minimise the risk of corrosion of the RCCA's and SCCA's assemblies. Further information was requested from GNSL with regard to the possible impact that the RCCAs and SCCAs could have on the drying of the SFAs. GNSL states that there will be limited impact on the drying process and that potentially a future operator could use additional measures to ensure that the level of dryness required was reached, so that the SFAs can be stored within the SFIS.

ONR is continuing to assess this area from a nuclear safety perspective, and this may result in changes to the management strategy. We will continue to engage with ONR as part of our ongoing assessment.

There are 3 types of ICIAs that are used within the UK HPR1000 core. These are types (i), (ii) and (iii), which we have discussed previously. The preferred option identified by GNSL for managing ICIAs was:

- placing a shielded winding machine on top of the reactor pressure vessel
- cutting the section of the ICIA, which is external to the reactor core, and disposing of this as LLW for metal recycling
- using the shielded winding machine to extract the remainder of the ICIA from within the core
- placing the wound ICIA within a robust shielded container, containing 160mm of stainless steel shielding
- transferring the type (iii) ICIAs to the ILW interim storage before consigning them to a GDF. Transferring the type (i) and (ii) ICIAs to the SFIS to decay storage to ILW before transferring to the ILW interim store

Further information has been requested from GNSL with regard to the management strategy for the ICIAs and the waste classification of the ICIAs. ONR is also currently assessing the use of the winding machine with regard to workers' safety, as this machine has never been used within the UK. Based on the current proposals and assuming that ONR's assessment does not alter the current strategy, the storage arrangements in place should not rule out any options for disposing of these wastes to a GDF.

Potential GDA Issue 5: GNSL is required to provide further substantiation of the proposed strategy for the management of in-core instrument assemblies (ICIAs) and if any changes to the strategy is decided, to assess the impact on the disposal of ICIA wastes.

Disposability of higher activity waste

We expect GNSL to obtain a view from RWM on the disposability of HAW (Environment Agency, 2016). We will also expect GNSL to consider the points RWM raised in its assessment, and to respond to the advice. Our P&ID document requires GNSL to identify a credible route for disposing of the HAW arisings from the UK HPR1000.

The overall objective of the disposability assessment process is to provide confidence that the conditioning and packaging of the HAW and spent fuel, for the UK HPR1000, will meet with RWM's current requirements for a GDF.

The RWM disposability assessment process has 3 main stages (see below), which a future operator will progress through to gain a letter of compliance (LoC) (NDA, 2014). A LoC demonstrates that the licensee's proposal is compliant with the current generic design of a GDF and its safety cases.

RWM's process for assessing the HAW arisings from the UK HPR1000 is very similar to that which would be performed at a siting stage. The 3 key parts of the RWM assessment process are:

- Phase 1 - Technical evaluation - which assesses the waste package data, nature and quantities of the wastes and the waste-form properties.
- Phase 2 - Design impact evaluations - where the GDF design impact and waste package properties are assessed.
- Phase 3 - Safety and environmental assessments - where the transport, operational and post closure safety is assessed as well as environmental considerations.

GNSL has sought advice from RWM with regard to its proposals for conditioning and packaging the HAW solid wastes that will arise from the UK HPR1000 (Table 9-4).

Table 9-4. The waste classification and the packaging of the HAW arising from the UK HPR1000

Waste stream	Waste classification	Container
Spent resins	ILW	Unencapsulated within a 500L robust shielded drum
Spent filter cartridges	ILW	Grout in 3m^3 box
Concentrates	ILW	Grouted in 500L drum
Sludges	ILW	Grouted in 500L drum
Reactor pressure vessel	ILW	Grouted 4m box
Reactor pressure vessel internals	ILW	Grouted in 3m^3 box
Decommissioning concrete	ILW	Grouted in 4m box
ICIAs	ILW	Unencapsulated within a 500L robust shielded drum with additional internal stainless steel shielding
Spent fuel	HLW	Spent fuel disposal container

Waste stream	Waste classification	Container
RCCAs	HLW	Spent fuel disposal container
SCCAs	HLW	Spent fuel disposal container

During the GDA assessment, GNSL made the decision to switch from Step 12 fuel to AFA 3GAA fuel produced by Framatome. In addition, RWM requested additional data from GNSL so that it could carry out the disposability assessment. Both factors have substantially impacted on the disposability assessment programme. We requested the following further information from GNSL:

- an updated disposability submission
- an updated delivery plan
- a disposability assessment report for our consultation technical assessment
- a final disposability assessment report and updated documentation by the end of GDA

GNSL has now submitted all the relevant information on the UK HPR1000 HAW and spent fuel to RWM (GNSL, 2020y).

An updated plan has also been provided and this gives us confidence that GNSL can provide us with a disposability assessment from RWM and update all supporting documentation by the targeted end of GDA.

GNSL has summarised the progress with regard to RWM's assessment within the UK HPR1000 HAW and Spent Fuel Disposability Assessment End of June Status Report (GNSL, 2020x). RWM has completed phase 1, phase 2 and the impact of disposal on human health and the natural environment for the ILW wastes. No issues have currently been identified. A potential issue may arise in relation to decommissioning wastes and the decay storage period before the waste is transferred to a GDF. However, this issue is not unique to the UK HPR1000 and has been identified for other reactors that have been assessed through GDA. For the spent fuel and non-fuel core components, phase 1 and phase 2 have been completed, with no issues having been identified.

In a number of cases, we note that the waste and packaging are similar to that used by other operators in the UK, such as the packaging of resins within robust shielded drums. We also note that for other GDAs the packaging of reactor pressure vessel (RPV) and reactor vessel internals (RVI) is similar and, therefore, we would expect that these wastes will be disposable subject to assessment by RWM. However, we note that, in some cases, there is limited UK experience of the wastes being packaged and conditioned using this approach.

We note that adding zinc to the primary circuit coolant could potentially impact on the grouting of the wastes and their final disposal. We have requested further information from GNSL on this area.

GNSL has also carried out an optioneering study to assess whether secondary neutron sources (SNS) can be removed during the operation of the UK HPR1000. However, it will be for a future operator to decide whether the SNS are removed.

We are confident that RWM's disposability assessment process will be completed by the targeted end of GDA, and it is likely that the wastes that will arise from the UK HPR1000 will be disposable. We have identified this as a potential GDA Issue (GDAI), as we could not issue a statement of design acceptability (SoDA) without evidence that the ILW and spent fuel will be disposable. However, should our Regulatory Observation be closed before the end of GDA, this potential GDAI will cease to be an issue.

Potential GDA Issue 6: GNSL is required to demonstrate that all higher activity waste (HAW) arisings from the UK HPR1000 will be disposable.

Records and knowledge management

GNSL indicates that a vast amount of information with regard to waste records will need to be managed and stored during the operational and decommissioning phases of the reactor's life cycle. A future operator will need to maintain these records to ensure that, in the future, the wastes arising from the UK HPR1000 will be disposable.

GNSL provided an overview of how it proposes to manage its records through its management and safety and quality assurance arrangements, which will be handed over to a future operator. However, it will be for a future operator to develop the specific systems and processes for managing waste package records. GNSL provided a general overview of what information is likely to be retained as part of a waste record, but this is not comprehensive. We noted that the information that will be collated as waste records is based on what GNSL has proposed. However, a future operator will need to engage with the operators of the disposal facilities to ensure that it captures their requirements for both LLW and HAW records. We have raised an Assessment Finding to ensure that this is the case:

Assessment Finding 25: A future operator shall engage with the operators of the disposal facilities to ensure that their requirements are complied with for both low activity wastes' and higher activity wastes' records.

As we previously mentioned within section 5.3.1, the UK has limited experience with regard to the dry storage of spent fuel and, in particular, its long-term storage. We note that GNSL is aware of the international experience in relation to the dry storage of spent fuel. We will expect a future operator to continue to make use of this knowledge and learn from it during the operational lifetime of the UK HPR1000.

Assessment Finding 26: A future operator shall continue to secure international OPEX with regard to the dry storage of spent fuels and ensure that it applies learning from the international OPEX to the storage of the UK HPR1000 fuel arisings.

GNSL highlighted the importance of retaining records and knowledge that arises during the operation of the UK HPR1000, to optimise the decommissioning of the UK HPR1000 reactor. Within its submission, GNSL has stated that establishing a decommissioning orientated records management system is seen as good practice to ensure that effective and efficient decommissioning is carried out for the UK HPR1000.

GNSL is aware of various decommissioning knowledge management repositories that exist internationally, which a future operator could benefit from. We support GNSL’s proposals to develop and make use of these repositories in order to support and optimise the decommissioning of the UK HPR1000.

Assessment Finding 27: A future operator shall secure and use OPEX, including that available internationally, to ensure that BAT is used to decommission the UK HPR1000 and that the generation of radioactive solid waste is minimised and it is capable of being disposed of.

Our overall preliminary conclusions on solid radioactive waste

There are still a number of ROs and RQs, raised by us and ONR, which will need to be addressed by the end of GDA. However, our preliminary conclusions are as follows:

- all solid and non-aqueous wastes have been identified
- a good description of the quantities, activities and composition for the majority of the solid wastes and spent fuel arisings has been provided. Further information will be provided by the end of GDA
- generally, a good description of how solid wastes and spent fuel arisings will be minimised at source is provided. However, there are a number of outstanding ROs and RQs that we are confident will be addressed before the end of GDA
- all LLW arisings from the UK HPR1000 would appear to be disposable, however we have questioned whether the approach to LLW concentrates and sludges is BAT. There are a number of issues for a future operator to address, at the site-specific phase
- we continue to assess whether the design of the UK HPR1000 has considered decommissioning and, therefore, minimised the generation of solid wastes. We are confident that GNSL will achieve this before the end of GDA
- we are confident that GNSL can apply effective characterisation and segregation to solid wastes for the UK HPR1000. However, a future operator will need to demonstrate that BAT is being applied
- we are confident that the conditioning and packaging options chosen for the HAW solid wastes can potentially produce disposable products, however RWM continues to assess these options
- we are confident that if GNSL can address the GDA Issue with regard to long-term storage of the spent fuel, the SFIS design will maintain the integrity of the spent fuel assemblies and, therefore, the assemblies will be disposable in the future
- the management strategy for the ICIAs could change and, therefore, impact on our assessment. A change in strategy could impact on the disposal of the wastes. However, at the time of writing this report, we see no reason why the current proposals could not lead to a disposable package
- we are confident that the waste packages proposed by GNSL are likely to be disposable, however we will assess RWM's assessment and how GNSL addresses any actions arising from the assessment
- the UK HPR1000 has demonstrated that BAT can be used to minimise the quantity (mass and volume) of solid radioactive waste that will need to be disposed of
- the quantities of solid radioactive waste produced will not exceed those of comparable power stations across the world
- optimal potential disposal routes have been identified for all lower activity solid wastes
- all higher activity solid wastes and spent fuel are likely to meet disposability criteria for the GDF
- the proposed arrangements for interim management of higher activity solid wastes and spent fuel are unlikely to prejudice their ultimate disposal

We have identified 3 potential GDA Issues and 14 Assessment Findings, as set out in the above paragraphs and at the beginning of this chapter.

More details of our assessment of solid radioactive waste can be found in our assessment report AR05 (Environment Agency, 2021e).

10. Sampling and monitoring of discharges and disposals of radioactive waste

This chapter covers our assessment of GNSL's proposed techniques to measure and assess discharges of radioactive waste to the environment and the activity content of solid wastes.

Such monitoring is necessary to:

- confirm that actual discharges are as predicted
- assess compliance with discharge limits
- provide good quality data for dose assessments
- characterise solid waste so it can be disposed of by the best routes
- inform a future operators actions and decisions

Our preliminary conclusion is that GNSL has demonstrated that BAT can be used to monitor discharges and disposals of radioactive waste.

We have identified 4 Assessment Findings:

Assessment Finding 28: A future operator shall address the post-GDA forward action plans identified in the 'Approach to Sampling & Monitoring' submission - HPR/GDA/PCER/0005, Revision 001-1, October 2020.

Assessment Finding 29: A future operator shall demonstrate, before the reactor is commissioned, that the final configuration of the sampling lines and the layout and positioning of the monitoring room are optimised to comply with ISO2889 and the use of best available techniques.

Assessment Finding 30: A future operator shall demonstrate that, before signing of the relevant procurement contracts, the selected sampling and monitoring equipment for determining the discharges are best available techniques and enables the EU recommended levels of detection to be met.

Assessment Finding 31: A future operator shall demonstrate that the systems and equipment used for monitoring and sentencing solid and non-aqueous liquid waste are best available techniques.

We want to ask you:

Consultation question 6:

Do you have any views or comments on our preliminary conclusions on monitoring discharges and disposals of radioactive waste?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Monitoring gaseous waste

Monitoring radioactive gaseous disposals is described in GNSL's 'Approach to Sampling and Monitoring' submission, including considerations of BAT (GNSL, 2020t). This includes both the approach to in-process and final discharge monitoring.

GNSL states that monitoring and sampling systems will be in place to enable activity concentrations to be determined for total noble gases (krypton-85 will not be measured specifically), cobalt-60, strontium-90, caesium-137 and total alpha (reported instead of individual alpha emitters) in particulate matter, iodine-131, tritium and carbon-14. Data provided by GNSL indicates that the required values from the EU Commission recommendation 2004/2/Euratom (EU, 2004) for detection limits can be met using currently available systems. We will require continuing compliance with this EU recommendation after the EU exit transition period.

The required nuclides are collected in a sequence that ensures the best sample, for each, is obtained. Particulates (for cobalt-60, strontium-90, caesium-137 and total alpha analysis) are collected first to minimise losses through plating out, the sample is then passed through an iodine adsorber before being passed into the gas chamber for the analysis of noble gases. This arrangement complies with BS EN 60761-3 (BSi, 2004). Tritium and carbon-14 are collected on different sample lines and the sampling units are expected to be bubbler systems, which trap the required radionuclide in a solution as the gas is bubbled through it.

There are 2 gaseous sampling points in the main stack feeding duplicate sampling and monitoring systems, which provides a spare system for use if the main sampler fails and allows for regulatory independent monitoring. Shrouded single nozzle sampling probes are used. This is considered good practice for sampling and collection systems to obtain representative samples for effluent streams containing particulate matter (Environment Agency, 2017a). Modelling work has been carried out to indicate where the gaseous effluent will become uniform in the stack to locate the sampling points and to evaluate the penetration factor to meet the requirements of BS ISO2889:2010 (BSi, 2010). A sampling platform designed to comply with our M1 technical guidance (Environment Agency, 2017b) will be provided to allow workers to have safe access for inspecting and maintaining the sampling equipment, including to the calibration ports. The total stack volumetric discharge flow will also be measured at the sampling points within the stack and additional flow measurements taken on the gaseous systems upstream of the main stack. Two calibration ports, located upstream of the flow meter, are proposed for periodic calibrations tests.

It is best practice to return the sample downstream of the sample extraction point to prevent either double counting or dilution of the sample. However, GNSL has proposed the sample return line be upstream of the extraction point, which saves pipework and the amount of potentially contaminated material that needs to be disposed of at the end of the plant life. Given this saving and the fact that the impact of the returning gas would be negligible due to the very small sample volume being diluted by the large stack flow rate (and any double counting being conservative), we have accepted this approach as BAT for the design.

In-process monitoring and sampling arrangements are provided to detect deviation from the normal state sooner than in the final discharge. If the gaseous activity concentration reaches an alarm threshold, a local sound-light alarm is triggered accompanied by an alarm displayed in the main control room.

We have assessed the information GNSL provided on the UK HPR1000 design for determining gaseous discharges against the requirements of our technical guidance notes M1 (Environment Agency, 2017b) and 245_17 (Environment Agency, 2017a) and relevant international and national standards (for example, BSi, 2010). The assessment also considered the commitment given to our MCERTS (Monitoring Certification) scheme for current in scope standards (Environment Agency, 2019) and flexibility to adopt future standards if nuclear facilities are within its scope.

Our preliminary conclusions are that:

- BAT has been broadly demonstrated for the UK HPR1000 gaseous effluent monitoring systems
- appropriate consideration has been given to the sampling line to ensure requirements for sampling can be met (through modelling penetration factors). Final confirmation of the acceptability of the sampling line will be needed once the position of the monitoring room has been finalised
- representative samples will be taken
- appropriate measurement and analysis will be carried out
- having the return of the sample to the discharge stack upstream of the sample extraction point will have a negligible effect on the discharge monitoring and is acceptable given the saving in pipework
- appropriate provision will be made to allow for independent regulatory verification of the gaseous monitoring and discharge reporting

There are a number of areas that a future operator will need to manage. GNSL has identified these and they are highlighted in GNSL's 'Approach to Sampling and Monitoring' submission (GNSL, 2020t). The monitoring of gaseous waste Assessment Findings are as follows:

Assessment Finding 28: A future operator shall address the post-GDA forward action plans identified in the 'Approach to Sampling & Monitoring' submission - HPR/GDA/PCER/0005, Revision 001-1, October 2020.

Assessment Finding 29: A future operator shall demonstrate, before the reactor is commissioned, that the final configuration of the sampling lines and the layout and positioning of the monitoring room are optimised to comply with ISO2889 and the use of best available techniques.

Assessment Finding 30: A future operator shall demonstrate that, before signing of the relevant procurement contracts, the selected sampling and monitoring equipment for determining the discharges are best available techniques and enables the EU recommended levels of detection to be met.

Monitoring liquid waste

Monitoring radioactive liquid disposals is described in GNSL’s ‘Approach to Sampling and Monitoring’ submission, including considerations of BAT. This includes both the approach to in-process and final discharge monitoring.

GNSL states that monitoring and sampling systems will be in place to enable activity concentrations to be determined for tritium, carbon-14, cobalt-60, strontium-90, caesium-137 and total alpha (reported instead of individual alpha emitters). All the main radionuclides required to meet EU Commission recommendation 2004/2/Euratom are being monitored (EU, 2004). While it is recognised that the detection limits achievable will depend on a number of parameters (including sample volume, measurement instrument and count time) that will only be finalised at later stages, GNSL has provided reference values indicating Euratom detection limits can be met using currently available systems.

We will require continuing compliance with this EU recommendation after the EU exit transition period.

The final discharge line receives liquid disposals from 2 sampling locations downstream of the aqueous waste treatment sub-systems that contain tanks for process, chemical, floor and laundry drains, and treatment systems, including demineralisers, evaporators and filters. When a storage tank is full it is manually isolated and locked to prevent additional input. A sample is collected once the storage tank is mixed, and the sample is analysed before being discharged to confirm the activity is less than the permitted activity. The discharge valve is interlocked with the inlet isolation valves of the tank to prevent liquid waste being discharged without being sampled and confirmed appropriate for discharge. The system is designed to prevent uncharacterised liquid waste being discharged into the environment.

As we require, GNSL has committed to the final accountancy samples being taken via flow proportional sampling systems on the final discharge line. Flow proportional samplers and flow measurement apparatus will be provided for both sampling locations and will allow independent verification by the regulator or our representatives. In addition to sample collection, a continuous radiation monitor is provided in the liquid discharge line. If the system detects a high radiation level, it activates an alarm and closes an isolation valve to stop discharge to the environment.

We have assessed the information GNSL provided on the UK HPR1000 design for determining liquid discharges against the requirements of our technical guidance note on monitoring radioactive discharges to water from nuclear sites (Environment Agency, 2020a). The assessment also considered the commitment given to our MCERTS (Monitoring Certification) scheme for current in scope standards (Environment Agency, 2014 and 2018b) and flexibility to adopt future standards if nuclear facilities are within scope.

Our preliminary conclusions are that:

- BAT has been demonstrated for the UK HPR1000 liquid effluent monitoring systems
- representative samples of the final discharge will be taken
- appropriate flow measurement will be carried out
- appropriate analysis will be carried out
- appropriate provision will be made to allow for independent regulatory verification of the liquid monitoring and discharge reporting

There are a number of areas that a future operator will need to address. GNSL has identified these and they are highlighted in its ‘Approach to Sampling and Monitoring’ submission. The monitoring of aqueous waste Assessment Findings are as follows:

Assessment Finding 28: A future operator shall address the post-GDA forward action plans identified in the 'Approach to Sampling & Monitoring' submission - HPR/GDA/PCER/0005, Revision 001-1, October 2020.

Assessment Finding 30: A future operator shall demonstrate that, before signing of the relevant procurement contracts, the selected sampling and monitoring equipment for determining the discharges are best available techniques and enables the EU recommended levels of detection to be met.

Monitoring solid and non-aqueous waste disposals

The monitoring of radioactive solid and non-aqueous liquid waste disposals is described in GNSL's 'Approach to Sampling and Monitoring' submission, including considerations of BAT. This includes a description of the sampling and monitoring arrangements for solid and non-aqueous liquid waste carried out at different stages in the complete waste cycle for the UK HPR10000 design, including proposed techniques. The stages include at or close to generation point, before processing, after processing (before and during storage), and before transfer to retrieval/repackaging or disposal or off-site treatment facilities.

Information on the solid and non-aqueous sampling and monitoring processes has taken account of relevant guidance, including guidance from the International Atomic Energy Agency (IAEA) (IAEA 2009a and 2009b). This gives reassurance that the practices being developed should be appropriate.

As the monitoring systems for the waste handling facilities have only been developed to concept level these will need to be assessed at a later stage. Our preliminary conclusion is that the practices being developed appear appropriate for monitoring the final disposal of solid wastes, but a full assessment needs to be carried out when more information has been provided.

We, therefore, have the following Assessment Finding:

Assessment Finding 31: A future operator shall demonstrate that the systems and equipment used for monitoring and sentencing solid and non-aqueous liquid waste are best available techniques.

Our overall preliminary conclusions on monitoring radioactive waste

Our preliminary conclusion is that the UK HPR1000 uses the best available techniques to monitor discharges and disposals of radioactive waste.

We have identified 4 Assessment Findings, as set out in the above paragraphs and at the beginning of this chapter.

More details of our assessment of the monitoring of radioactive waste can be found in our assessment report AR06 (Environment Agency, 2021d).

11. Impact of radioactive discharges

This chapter covers our assessment of the impact of the proposed radioactive discharges from the UK HPR1000 - that is, the radiation doses that people and other species might receive. We compare the calculated doses with national and international limits and standards to confirm that people and the environment will be adequately protected.

Dose calculations rely on models that predict how radioactivity from discharges moves through the environment and causes people and other species to be exposed to radiation, either externally or by breathing in air, drinking water or eating food. In GDA, we are not dealing with specific sites, so the dose calculations need to be done on the basis of a 'generic site' that has characteristics appropriate to sites in the UK, where nuclear power stations might be built. To be able to properly compare with standards and limits, the calculations include the predicted external radiation that comes directly from the nuclear power station, although this is a regulatory matter for ONR rather than the Environment Agency.

Our preliminary conclusion is that, for the operation of a single unit of the UK HPR1000 at any estuarine or coastal site identified as suitable for new nuclear power stations (GB Parliament, 2011) and with discharges at the annual limits specified in chapters 10 and 11:

- the radiation dose to people will be below the UK constraint for any single new source of 300 micro Sieverts per year (µSv/y)
- the radiation dose-rates to local plant and animal life will be below our screening level of 10 micro Grays per hour (µGy/h) and so there will not be any significant adverse impact on non-human species

We have not identified any potential GDA Issues or Assessment Findings.

We want to ask you:

Consultation question 7:

Do you have any views or comments on our preliminary conclusions on the impact of discharges of radioactive waste?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Generic site description

We examined GNSL's generic site description in some detail during our initial assessment (Environment Agency, 2018a).

We noted that some additional information related to the generic site was required. This is because this forms input data to the dose assessment for public and wildlife. The additional information required included:

- the assumed area/size of the site
- the nature and shape of the coast (estuary or open coastline)
- the assumed position of the site on the coast

- the type of terrestrial environment (land) around the site (urban, rural or agricultural)
- the assumed position where discharges to atmosphere occur on the site
- the assumed marine environment into which liquid discharges and cooling water discharges occur - enclosed estuary or open coastal environment

Dose assessments

We also examined GNSL's dose assessment in some detail during our initial assessment (Environment Agency, 12018a) and concluded that:

- the annual dose constraints and limits will not be exceeded by this design
- the action level for non-human species will not be exceeded by this design

However, we did require some further information:

- We asked GNSL whether a stage 3 dose assessment will be made (RQ-UKHPR1000-0061) and GNSL committed to carry this out.
- We required clarification on the method used to calculate the impact from short duration releases (RQ-UKHPR1000-0062).
- We required further justification for using our initial radiological assessment tool (IRAT) as a suitable modelling tool (RQ-UKHPR1000-0063).
- We required further information on the accumulation of radioactivity over time in the environment (such as in soils and sea bed sediments).
- We also noted that further work was required on demonstrating that the direct dose component was appropriate.

These revised and new assessments are discussed in the sections below.

Annual doses to individuals

GNSL carried out a stage 1 and stage 2 assessment using our IRAT screening tool (Environment Agency, 2006a and 2006b). If the total dose from the stage 1 assessment is above 20µSv/y, the assessment should be refined in a stage 2 assessment. If the total dose from the stage 2 assessment remain above 20µSv/y threshold, a third stage assessment should be carried out using a more detailed model.

For the assessment, discharges of radioactivity are assumed to occur as liquids and to atmosphere as gases and small amounts of particulate matter. The results of the GNSL stage 1 and stage 2 assessments assuming exposure to discharges at the proposed limits are presented in Table 11-1. The total dose at each stage was above the 20µSv/y screening threshold, requiring GNSL to carry out a more detailed assessment.

Table 11-1 GNSL outcomes for the stage 1 and stage 2 dose assessments using IRAT (GNSL 2020g).

Route	Stage 1 doses (µSv/y)	Stage 2 doses (µSv/y)
Liquid discharges	27.8	21.4
Discharges to atmosphere	140	22.3
Direct radiation	6.3	6.3
Total	174	50.0

GNSL has carried out a stage 3 assessment, which is presented in the 'Pre-Construction Environmental Report (PCER, chapter 7 (GNSL, 2020ac) using site parameters taken from the PCER chapter 2 (GNSL, 2020ad) and assuming exposure to discharges at the proposed limits.

We have reviewed the approach against the relevant dose principles and guidance and reviewed the assumptions and parameters of the assessment. We asked for clarification via RQs on the following:

- which dose criteria quoted in the PCER were applicable to the GDA process (RQ-UKHPR1000-0201)
- the location of the marine discharge point, estuarine or marine and the justification and impact of selecting Bradwell characteristics for model input data (RQ-UKHPR1000-0202)
- the validity for using the Environmental Permitting Regulations as a reference for text relating to regulatory thresholds (RQ-UKHPR1000-0203)
- the coherent presentation of dose assessment results (RQ-UKHPR1000-0204)
- the assessment of dose to foetus (RQ-UKHPR1000-0517)
- justification for selecting atmospheric dispersion parameters, selecting the short duration release source term, and the stack height used (RQ-UKHPR1000-0518)
- the selection, presentation and use of habit data in the dose assessment (RQ-UKHPR1000-0519)
- the consistency of presentation of information relating to the consumption rates derived using the 'top two' method across the PCER and supporting documentation (RQ-UKHPR1000-0520)
- the selection of meteorological parameters and physical characteristics of the discharge used for the short duration release modelling (RQ-UKHPR1000-0521)
- the accuracy or clarity of the calculation of the stage 2 assessment results (RQ-UKHPR1000-0522)
- the predicted accumulation of radionuclides in soil, marine sediment and marine waters over the 60 years of operation (RQ-UKHPR1000-0523)
- the location of receptors and food production (RQ-UKHPR1000-0828)
- the applicability of the dose principles to GDA, the calculation of external plume irradiation, air concentrations at receptor locations used in both the assessment of continuous short duration releases and the applicability of the IAEA guidance referenced in the PCER (RQ-UKHPR1000-0829)

We also asked our technical support contractor (TSC) to carry out an independent dose assessment on our behalf to provide a reference point to compare with the GNSL submission (Environment Agency 2021i). We found that:

- the generic site description used information that is consistent with the bounding case for the UK as it is representative of the Bradwell site
- the meteorological data selected for the stage 3 assessment (Pasquil stability - 65% Category D) was representative of a typical UK coastal site
- GNSL had selected a conservative volumetric exchange rate for marine modelling, which represents a low dispersion environment, giving a conservation dose estimate. We agree it is appropriate to use a conservative approach for GDA
- GNSL's selection of receptors (exposed people, wildlife and food production) assumed that people and wildlife were located 100m from the site and food was produced 500m from the release point. It was not clear why these parameters were chosen and so we asked for clarification (see RQ-828 noted above). Our independent assessment (Environment Agency, 2021i) showed that the distance of maximum ground level air concentration was between 200 and 300m. This suggests that the GNSL parameter selection is not a bounding case for exposure to atmospheric release, but probably is for direct radiation. Selecting 300m gives higher ground level air concentrations but lower direct radiation
- the habit data used in the stage 3 assessment was based on UK generic data, supplemented with data representative of the UK Bradwell site, where the latter was more conservative. We are content that the data are appropriate to use for a generic site. Supplementing habits data for the generic site with data representative of the UK Bradwell site habit data (where the Bradwell site data is higher) will lead to a more cautious (higher) estimate of dose to the public

Further information on the parameters selected and our assessment of them can be found in our full assessment report (Environment Agency, 2021g).

The results of the GNSL dose assessment are presented in Table 11-2. For comparison, the results of our independent dose assessment are also presented in Table 11-3.

Table 11-2, GNSL outcomes for the stage 3 dose assessments using PC CREAM 08 (GNSL, 2020g).

Table 11-2a GNSL - Overall prospective dose μSv/y to the local fishing family (most exposed to liquid discharges)

Age group	Liquid discharges	Discharges to atmosphere	Direct exposure	Total
Adult	11.2	5.3	6.3	22.8
Child	4.3	4.9	3.2	12.4
Infant	0.9	6.5	2.2	9.6

Table 11-2b GNSL - Overall prospective dose µSv/y to the local resident family (most exposed to discharges to atmosphere)

Age group	Liquid discharges	Discharges to atmosphere	Direct exposure	Total
Adult	2.2	9.8	6.3	18.3
Child	3.0	9.6	3.2	15.8
Infant	0.6	15.1	2.2	17.9

Table 11-3, Our independent assessment outcomes for the stage 3 dose assessments using PC CREAM 08 (Environment Agency, 2021i)

Table 11-3a Overall prospective dose µSv/y to the local fishing family (most exposed to liquid discharges)

Age group	Liquid discharges	Discharges to atmosphere	Direct exposure	Total
Adult	8.0	7.0	0.44	15.4
Child	2.4	7.7	0.22	10.3
Infant	0.61	9.8	0.15	10.6

Table 11-3b Overall prospective dose µSv/y to the local resident family (most exposed to discharges to atmosphere) - from our independent dose assessment

Age group	Liquid discharges	Discharges to atmosphere	Direct exposure	Total
Adult	0.98	11	0.44	12.4
Child	0.68	12	0.22	12.9
Infant	0.43	21	0.15	21.6

Short-term doses to individuals

The assessment of annual doses assumes that discharges are evenly spread throughout the year. However, some discharges may occur intermittently and over a short period (see chapters 10 and 11). The dose per unit discharge for short-term discharges can be higher than that for continuous discharges, depending on factors such as the time of year, the prevailing weather conditions and the state of nearby pasture or crops.

PC CREAM 08 is only suitable for assessment of dose that is continually discharged over a full year. Therefore, we require suitable models to be used to determine the impact of a short duration release. Also, based on National Dose Assessment Working Group guidance (NDAWG, 2019), assessment of short duration release should only be carried out for discharges to atmosphere.

GNSL has submitted a dose impact assessment for a short duration release (GNSL. 2020ac) which uses ADMS aerial dispersion modelling. This model uses dispersion parameters that are aligned with those used for the annual dose assessment. However, GNSL assumes that the maximum monthly discharge occurs in a 24-hour period. We tested this assumption in our independent dose assessment (Environment Agency, 2021i) as part of a sensitivity analysis. This showed that the results were similar whether the discharges were assumed to occur over a 24-hour release or a 6-hour release. Therefore, we are content that this is an appropriate assumption. GNSL also assumed that the release occurred in late summer, at peak growing season. This is a conservative assumption where maximum radioactivity will be transferred into foodstuffs and is appropriate for GDA.

Further information on the parameters selected and our assessment of them can be found in our full assessment report (Environment Agency, 2021g).

The results of the GNSL short duration release dose assessment are presented in Table 11-4. For comparison, the results of our independent dose assessment are also presented in Table 11-5.

Table 11-4, GNSL outcomes for the stage 3 dose assessments of a short duration release (GNSL, 2020g).

Table 11-4 Dose μSv to the local resident family most exposed to a short-term discharge to atmosphere.

Age group	Total
Adult	5.8
Child	5.8
Infant	9.7

Table 11-5, Our independent assessment outcomes for the stage 3 dose assessments of a short duration release (Environment Agency, 2021i).

Table 11-5 IDose μSv to the local resident family most exposed to a short-term discharge to atmosphere.

Age group	Total
Adult	6.9
Child	6.0
Infant	7.8

Collective doses

Collective dose is the sum of all the doses received by the members of a population over a specified period of time. It can be useful when comparing different process or disposal options. Collective doses are measured in man-Sievert per year of discharge (manSv/y).

GNSL has used the collective dose outputs from the PC CREAM 08 model to calculate individual dose impact. Results have been calculated for the UK, Europe and the world over 500 years for one year of discharge. The model used and the underpinning assumptions are appropriate to use to derive collective dose.

Further information on the parameters selected and our assessment of them can be found in our full assessment report (Environment Agency, 2021g).

The results of the GNSL collective dose assessment are presented in Table 11-6. For comparison, the results of our independent dose assessment are also presented in Table 11-7.

Table 11-6. GNSL outcomes for collective doses (man-Sv/y)

Population	Collective dose from liquid discharges	Collective dose from discharges to atmosphere	Total
UK	0.013	0.68	0.69
EU-12	0.078	3.59	3.67
EU-25	--	3.88	3.88
World	0.743	29.7	30.4

Table 11-7. Our independent assessment outcomes for collective dose (man-Sv/y)

Population	Collective dose from liquid discharges	Collective dose from discharges to atmosphere	Total
UK	0.013	0.71	0.72
EU	0.078	4.1	4.18
World	0.74	30	30.7

Doses to non-human species

GNSL has carried out an assessment of doses to non-human species, which is presented in the Pre-Construction Environmental Report (PCER, Chapter 7 (GNSL, 2020ac) using site parameters taken from the PCER Chapter 2 (GNSL, 2020ad). GNSL used the ERICA system (Environmental Risk from Ionising Contaminants: Assessment and Management) for their assessment. Doses are expressed as dose rates (µGy/h).

We have reviewed the assumptions and parameters of the assessment and we asked for clarification via RQs on the following:

- presentation of dose rates by radionuclide for all species, a justification for changing default model parameters (partition coefficients and concentration factors) and the specific ERICA input parameters used for H-3 and C-14 air concentration (RQ-UKHPR1000-0205)
- the response to RQ-HPR1000-0205, which appeared to be incomplete (RQ-UKHPR1000-0249)
- the choice of reference organisms used (RQ-UKHPR1000-0518)
- the location of receptors (RQ-UKHPR1000-0828)
- the accuracy of the dose rates from noble gases, tellurium and zirconium, presented in the assessment, the concentration ratios selected for use in ERICA and accuracy of cross referencing within the PCER chapter (RQ-UKHPR1000-0830)

We also asked our technical support contractor (TSC) to carry out an independent dose assessment on our behalf to provide a reference point to compare with the GNSL submission (Environment Agency 2021i). We found that:

- GNSL has used the appropriate tools to carry out its dose assessment for wildlife, ERICA (Beresford et al. 2007, Brown et al., 2007, Brown et al., 2016) and the Ar-Kr-Xe dose calculator (Vives i Batlle et al., 2015)
- GNSL uses reference organisms to represent sensitive habitats and protected species which may be located at the generic site. We are content that using the ERICA reference organisms approach is appropriate for the GDA stage
- GNSL calculated the accumulation of radionuclides in air, soil and seabed sediment from the HPR1000 over an assumed 60-year period of operations. These environmental activity concentrations were used as input data into the wildlife dose assessments
- these environmental activity concentrations were calculated using the same generic site parameters and assumptions used for calculating individual doses, see above. We are content that these data and assumptions are suitably conservative for this assessment. GNSL assumed that there was no fresh water on site and, therefore, no fresh water species were considered. While this is acceptable at GDA, fresh water species are likely to need considering at the site-specific stage of permitting, if present or near the site
- when we repeated the noble gas assessment, results for dose rates from argon-41 and also the dose rates to the reference organism shrub were not consistent. From our investigation, it appears that GNSL has inaccurately transcribed some results from the Ar-Kr-Xe dose calculator tool. However, we are content that these inaccuracies are limited to GNSL's reporting errors and are not as a result of using the tool inaccurately or using inappropriate input data. Impact on the overall result is negligible
- GNSL has shown that the dose rates to reference organisms in the terrestrial and marine environments are well below the dose rate criterion of 10µGy/h and that the probability that the dose rate criterion of 10µGy/h would be exceeded was less than 1%

Further information on the parameters selected and our assessment of them can be found in our full assessment report (Environment Agency, 2021g).

The results of the GNSL collective dose assessment and, for comparison, the results of our independent dose assessment are also presented in Table 11-8.

Table 11-8: Results of GNSL's and our assessment of dose rates to wildlife

Table 11-8a Terrestrial assessment from discharges to atmosphere (Highest dose rate to worst affected reference organism (µGy/h))

Data source	GNSL results	Our results
GNSL	0.15 (reptile)	0.14 (bird)
Independent assessment	Not applicable	0.13 (mammal - large and small burrowing)

Table 11-8b Marine assessment from liquid discharges (Highest dose rate to worst affected reference organism (µGy/h))

Data source	GNSL results	Our results
GNSL	0.0063 (polychaete worm)	Same as GNSL
Independent assessment	Not applicable	0.023 (mammal)

Comparison with standards

There are a number of dose limits and constraints which any new nuclear station would have to meet.

Source dose constraint

The source dose constraint (GB Parliament, 2016) is 300µSv/y. It applies to the dose from proposed discharges and direct radiation from a new single source (for example, a new nuclear power station). The total annual doses - assessed by GNSL and our independent assessment - to the representative person are between 10 and 23µSv/y depending on exposed group and age group. These doses include the dose from discharges and direct radiation and are well below the source constraint of 300µSv/y.

Site dose constraint

The site dose constraint (GB Parliament, 2016) is 500µSv/y. It applies to the total dose from future discharges from all sources at a single location, including discharges from immediately adjacent sites. Doses arising from direct radiation and historical discharges are not included in the comparison with the site constraint. All the sites listed in NPS EN-6 (GB Parliament, 2011) as potentially suitable for a new nuclear power station are adjacent to existing nuclear sites. Of these 8 sites, representative persons at Sellafield from future discharges have the highest assessed dose for discharges at future permit limits for discharges - which range from 63 to 108µSv/y (Environment Agency, 2020c). The doses from discharges from one UK HPR1000 reactor (without direct radiation) assessed by GNSL and in our independent assessment range from 10 to 23µSv/y. For 2 reactors the dose could be 20 to 46µSv/y. Total dose for comparison with the site constraint is, therefore, between 83 and 154µSv/y, which is well below the site dose constraint of 500µSv/y.

Dose limit for the public

The dose limit (GB Parliament, 2010) for members of the public is 1,000µSv/y. It applies to the total dose from the future discharges from the site, direct radiation from the site, future discharges from other sources near the site, direct radiation from other sources near the site, and the residue of radioactivity in the environment from past discharges. All the sites listed in NPS EN-6 (GB Parliament, 2011) as potentially suitable for a new nuclear power station are adjacent to existing nuclear sites. Of these 8 sites, representative persons on the west coast of Cumbria near Sellafield have been shown to receive the highest doses to date. These include all sources: the legacy of historic discharges from the phosphate works at Whitehaven; past discharges from Sellafield; future discharges from Sellafield and direct radiation from Sellafield. The doses have been dominated by the legacy of historic discharges from the phosphate works and show considerable variation from year to year. Since 2013, doses from all sources range from 130 to 530µSv/y (Environment Agency, 2020c).

The doses from one UK HPR1000 reactor assessed by GNSL and in our independent assessment range from 10 to 23µSv/y. For 2 reactors the dose could be 20 to 46µSv/y.

If 2 UK HPR1000 reactors were operated at a site next to Sellafield it could lead to total doses of between 150 and 576µSv/y. This is below the dose limit for members of the public of 1,000µSv/y.

Effect of short-term releases

In the event of an enhanced short duration release to the atmosphere during the operational cycle, the additional assessed dose is up to a maximum of 9.7µSv (infant age group). This would not cause the source constraint, site constraint or dose limit to be exceeded. If the dose from a single short duration releases is included with doses to the public the total from one reactor could be up to 29µSv/y. This is below the dose constraint of 300µSv/y.

Collective dose

There are no limits or constraints for collective dose. However, Public Health England has advised, in relation to authorising discharges, calculating an average dose to members of the population (per person doses) and that, if that average is in the nano-Sievert (nSv) per year range or below, the collective dose does not need to be considered further in the decision-making process (HPA, 2009). The per person doses set out below (Table 11-9) all meet this criterion.

Table 11-9. GNSL outcomes for average individual doses to the population (derived from collective dose)

Population	Dose from liquid discharges (nSv/y)	Dose from discharges to atmosphere (nSv/y)
UK	0.22	11.4
EU-12	0.22	10.0
EU-25	-	8.5
World	0.007	2.97

Non-human species

For non-human species, we use an action level of 40µGy/h. This is the level below which we consider there will be no significant adverse effects on non-human species. Because non-human species may be affected by discharges from more than one site, we also use a screening level of 10µGy/h when considering the impact from a single source. The highest assessed dose-rates for the terrestrial environment range from 0.13µGy/h (burrowing mammal) to 0.15µGy/h (reptile). The highest assessment doses in the marine environment range from 0.0063µGy/h (polychaete worm) to 0.023µGy/h (mammal). All dose rates are well below the screening level of 10µGy/h.

Our overall preliminary conclusions on the impact of radioactive discharges

Our preliminary conclusion is that, for the operation of a UK HPR1000 at any estuarine or coastal site identified as suitable for new nuclear power stations (GB Parliament, 2011) and with discharges at the proposed annual limits specified in chapters 10 and 11:

- the radiation dose to people will be below the UK constraint for any single new source of 300 micro Sieverts per year (µSv/y)
- the radiation dose-rates to local plant and animal life will be below our screening level of 10 micro Grays per hour (µGy/h) and so there will not be any significant adverse impact on non-human species from radioactive discharges

We have not identified any potential GDA Issues or Assessment Findings.

More details of our assessment of the impact of radioactive discharges can be found in our assessment report AR07 (Environment Agency, 2021g).

12. Our overall preliminary conclusion on radioactive substances permitting

In this document we are presenting our preliminary conclusions so far. We will continue to assess any developments in the submissions from the Requesting Party and will carefully consider all responses to this consultation before making our final conclusions.

On the basis of our work so far, our preliminary conclusion is that, a SoDA could be issued if all potential GDA Issues are resolved and no new potential GDA issues arise before the end of detailed assessment. If not resolved, we could only issue an iSoDA until the GDA Issues were resolved.

On issue of a SoDA it would mean that the design is suitable for use in England, subject to any developer securing all relevant permits, licences and consents. The iSODA or SoDA would be valid only for a site meeting the identified generic site characteristics.

A future operator would also have to address the Assessment Findings of this GDA at an appropriate point in the site development programme.

We want to ask you:

Consultation question 8:

Do you have any views or comments on our preliminary overall conclusion on radioactive substances permitting?

13. Water use and abstraction

This chapter covers our assessment of water use and abstraction.

Nuclear power stations need fresh water to use in the steam-raising circuits, other processes and 'domestic' purposes (for example, showers, toilets, laundry). They also need fresh or sea water for cooling the steam condensers and other plant. Where water supplies are abstracted directly from groundwater (for example, via boreholes) or inland waters (for example, lakes, rivers or estuaries), a water abstraction licence is required.

Our preliminary conclusions are that:

- an abstraction licence would not be required for fresh water supply (for example, process and drinking water) if it is provided by a local water company
- an abstraction licence would not be required if cooling water is abstracted from open coastal waters, but it is likely to be required if an estuary location is chosen
- the choice of once-through sea water cooling could be considered appropriate for the UK HPR1000 based on a coastal or estuary location. However, other options can be considered at site-specific stage depending on site-specific characteristics (including ecology and biodiversity)
- the final design of the abstraction intake and fish deterrent and return systems for the UK HPR1000 to minimise fish ingress and injury and meet the requirements of the Eels (England and Wales) Regulations 2009 (GB Parliament, 2009b), and other legislation as relevant, is a site-specific issue and can only be determined once the local environmental conditions are known

We have identified no potential GDA Issues and 2 Assessment Findings.

Assessment Fining 32: A future operator shall engage with the local water supply company early in the site-specific stage. This is to ensure that sufficient quantities of fresh water can be supplied to meet the requirements of the UK HPR1000 or to determine whether an alternative source of fresh water will need to be identified.

Assessment Finding 33: A future operator shall ensure that the siting of the cooling water intake and outlets are BAT for the UK HPR1000 design at each specific site.

We want to ask you:

Consultation question 9:

Do you have any views or comments on our preliminary conclusions on water abstraction?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Fresh water requirements

Information on other water use (fresh water) is provided in GNSL's Pre-Construction Environmental Safety Report (PCER) on Conventional Impact Assessment' (GNSL, 2020f).

GNSL states that the GDA is based on the assumption that all fresh water requirements will be supplied by the local water company. This means that there will be no fresh water abstraction and, therefore, an abstraction licence is not required for the generic design. The RP considers fresh water supply to be a site-specific matter and leaves all options open for a future operator to consider. In order to ensure the need to explore all options is sufficiently highlighted, we consider the following Assessment Finding to be appropriate:

Assessment Fining 32: A future operator shall engage with the local water supply company early in the site-specific stage. This is to ensure that sufficient quantities of fresh water can be supplied to meet the requirements of the UK HPR1000 or to determine whether an alternative source of fresh water will need to be identified.

There are 3 parts of the design which use fresh water:

- demineralised water - estimated normal consumption 490m^3/day
- process water - estimated normal consumption 734m^3/day
- potable (drinking) water - estimated normal consumption 315m^3/day

By taking into account several factors such as the expected plant availability and daily variations in usage, the Requesting Party (RP) has concluded that the total annual fresh water consumption will be approximately 405,835m^3/yr.

We consider the estimated fresh water requirement to be reasonable for the design, but will encourage a future operator to continually monitor and minimise fresh water usage throughout the life cycle of the facility.

Cooling water requirements

Information on cooling water is provided in GNSL's Pre-Construction Environmental Safety Report (PCER) on Conventional Impact Assessment' (GNSL, 2020f).

GNSL states that the generic site being considered for GDA is a coastal or estuarine site. An abstraction licence would not be required if cooling water is abstracted from open coastal waters, but it is likely to be required if an estuary location is chosen.

Cooling water is used in 3 systems in the UK HPR100 design:

- Circulating water system - this system supplies cooling water to the turbine condenser and the auxiliary cooling water system. The water is abstracted from the environment, used to cool the heat exchanger equipment then discharged back to the environment.
- Essential service water system - this system uses abstracted water to cool the heat exchanger in the component cooling water system and then discharge it back to the environment.
- Auxiliary cooling water system - this system takes some water from the main circulating water system to supply the conventional island closed cooling water system coolers and the condensate vacuum system coolers before discharge back into the environment.

GNSL has concluded that it considers a once-through cooling system to be the most appropriate environmental option for the UK HPR1000 design based on the generic site characteristics (coastal or estuarine site). GNSL has been clear in its submission that other cooling water systems could be used in a site-specific UK HPR1000 design. A future operator will need to justify the decision to use a once-through system or an alternative type of cooling system at the site-specific stage in order to demonstrate that it is the best available technique (BAT). We consider the following Assessment Finding appropriate to ensure this happens:

Assessment Finding 33: A future operator shall ensure that the siting of the cooling water intake and outlets are BAT for the UK HPR1000 design at each specific site.

Inevitably, the 3 cooling water systems will discharge water at a higher temperature than it was abstracted at. GNSL has proposed a total temperature rise of 9.7^{o}C. Under normal operating conditions, GNSL has estimated the cooling water requirements to be in the region of 198,000m^3/hr, which would drop to approximately 2,700m^3/hr during outage.

The quantity and temperature rise figures presented by GNSL are similar to other reactor designs that have been subject to the GDA process and to existing operational nuclear power stations in the UK.

The abstracted sea water needs screening to remove debris before it can be used. However, screens can trap and damage fish and other invertebrates, so fish deterrent and return systems are needed. Operators abstracting more than 20m^3/day or discharging water back to any channel, sea or bed are subject to the requirements of the Eels (England and Wales) Regulations 2009 and must screen the abstraction or discharge to prevent eels becoming trapped, unless an exemption notice has been granted.

GNSL in its 'Conventional Impact Assessment' (GNSL, 2020f) submission has described the different types of screens that could be used in the UK HPR1000 design, along with the other types of barriers and techniques for capturing and returning fish and eels back to the environment. The location of cooling water abstraction intakes and the design options to minimise fish ingress and injury to meet the requirements of the Eels Regulations 2009 (GB Parliament, 2009b) depend greatly on the local environment. It is, therefore, reasonable to conclude that this can only be determined at the site-specific stage - we agree with this conclusion.

Our overall preliminary conclusions on water abstraction

Our preliminary conclusions are that:

- an abstraction licence would not be required for fresh water supply (for example, process and drinking water) if it is provided by a local water company
- an abstraction licence would not be required if cooling water is abstracted from open coastal waters, but it is likely to be required if an estuary location is chosen
- the choice of once-through sea water cooling could be considered appropriate for the UK HPR1000 based on a coastal or estuary location. However, other options can be considered at the site-specific stage depending on site-specific characteristics (including ecology and biodiversity)
- the final design of the abstraction intake and fish deterrent and return systems for the UK HPR1000 to minimise fish ingress and injury and meet the requirements of the Eels (England and Wales) Regulations 2009 (GB Parliament, 2009b) is a site-specific issue and can only be determined once the local environmental conditions are known

We have identified no potential GDA Issues and 2 Assessment Findings, as set out in the above paragraphs and at the beginning of this chapter.

More details of our assessment of water use and abstraction can be found in our assessment report AR08 (Environment Agency, 2021h).

14. Discharges to surface waters and groundwater

This chapter covers our assessment of discharges of non-radioactive contaminants to surface waters (for example, lakes, rivers and the sea) and groundwater.

Non-radioactive contaminants include the heat transferred to the cooling water, as well as process wastes and other polluting matter. We assess the environmental impact of the discharges by comparing the predicted concentrations of contaminants in the receiving waters against relevant environmental standards. The thermal impact of the cooling water discharges is assessed at the site-specific stage.

Following our assessment of the surface water discharges, our preliminary conclusions are that:

- the UK HPR1000 will have non-radioactive discharges to surface water and will require an environmental permit for a water discharge activity
- the information GNSL provided for GDA is sufficient for us to conclude that the impact from discharges to surface waters could be at levels low enough to enable a reasonable application for a water discharge activity permit. However, the risk assessment work carried out for GDA must be revised with greater detail at site-specific permitting stage to reduce the level of uncertainty in the work carried out to date. At the site specific stage all necessary permissions must be applied for and obtained by the future operator.

Following our assessment of discharges to groundwater, our preliminary conclusion are that:

- there should be no intentional discharges to groundwater, and an environmental permit for a groundwater activity will not be required
- the pollution prevention techniques specified in the design should prevent contamination of groundwater. If any of the generic design assumptions change at a site-specific stage, then this preliminary conclusion will need to be reconsidered

We have identified no potential GDA Issues and 3 Assessment Findings.

Assessment Finding 34: A future operator shall review the calculations for emissions of chemicals as part of the site-specific environmental risk assessment. Particular attention should be focussed on the application of possible treatment techniques for hydrazine to reduce the amount discharged to the environment, and therefore minimise any impact.

Assessment Finding 35: A future operator shall ensure that the storage, treatment and monitoring systems for the 3 non-radioactive effluent streams provide the appropriate level of environmental protection for the receiving environment in terms of quality of effluent discharged. This would be regulated by a water discharge activity permit.

Assessment Finding 36: A future operator shall provide in an application for a water discharge activity environmental permit a site-specific environmental impact assessment for discharges to water. The modelling shall use site-specific

parameters based on the environmental setting and the specific chemicals selected for use.

We want to ask you:

Consultation question 10:

Do you have any views or comments on our preliminary conclusions on discharges to surface waters and groundwater?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Discharges to surface waters

Information on discharges to surface waters is provided in GNSL's Pre-Construction Environmental Safety Report (PCER) on Conventional Impact Assessment' (GNSL, 2020f).

The liquid effluent management systems in the UK HPR1000 design are quite complex, but can be simplified by considering 3 main types of liquid effluents associated with:

- radioactive waste streams
- non-radioactive waste streams
- the cooling water systems

The environmental impact in terms of the physical and chemical composition of these 3 effluent streams would be controlled by a water discharge activity permit issued under the Environmental Permitting Regulations 2016 (GB Parliament, 2016), which would be required at site-specific permitting stage.

Effluents associated with radioactive waste streams

In the UK HPR1000 design liquid radioactive effluents can be categorised as:

- process drains - characterised by a low level of chemical impurities
- chemical drains - characterised by a higher level of chemical impurities
- floor drains - characterised as being typically high in suspended solids
- laundry drains - characterised as being typically high in suspended solids and detergents

These effluent streams are managed and treated separately up to the point at which they enter the 'nuclear island liquid waste discharge system' (NLWDS) - see Figure 14-1 below. Treatment of these effluent streams takes place in the 'liquid waste treatment system' (LWTS). The process drain effluents are treated by demineralisation, chemical drain effluents are treated by evaporation, and the floor and laundry drains are treated by filtration. The treatment options for these effluents are intended to treat radioactive as well as chemical contaminants.

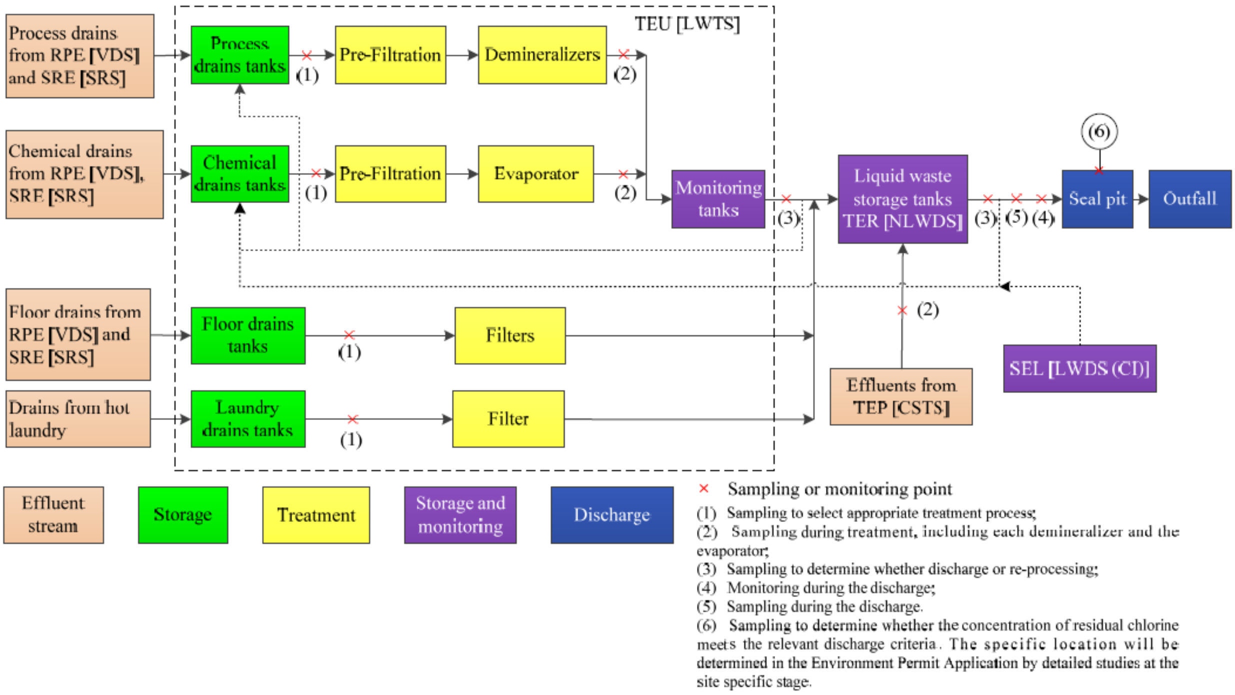

Figure 14-1: GNSL flow diagram for liquid radioactive effluent streams (GNSL, 2020f)

Figure 14-2 below shows the systems that are used to manage potentially radioactive effluents from the turbine hall (waste fluid collection system for conventional island - WFCSCI) and steam generator blowdown system (SGBS) before they go to the conventional island liquid waste discharge system (LWDS(CI)). The turbine hall effluents also have the potential to be oily so the waste fluid collection system for conventional island (WFCSI) is split into two parts - part 1 treats the potentially oily wastes while part 2 deals with the non-oily effluents. The potentially radioactive, oily effluents are treated by conventional oil/water separation techniques which removes the oil fraction from the effluent stream and is then dealt with separately by off-site recovery or disposal. The remaining water fraction is sampled in storage tanks in the LWDS(CI) and then either released for discharge via the seal pit or directed to the appropriate treatment facility in the LWTS (see figure 14-1 & 14-2). The seal pit is a structure designed to prevent air getting back into the cooling water and effluent systems and is linked to the main site outfall into the environment.

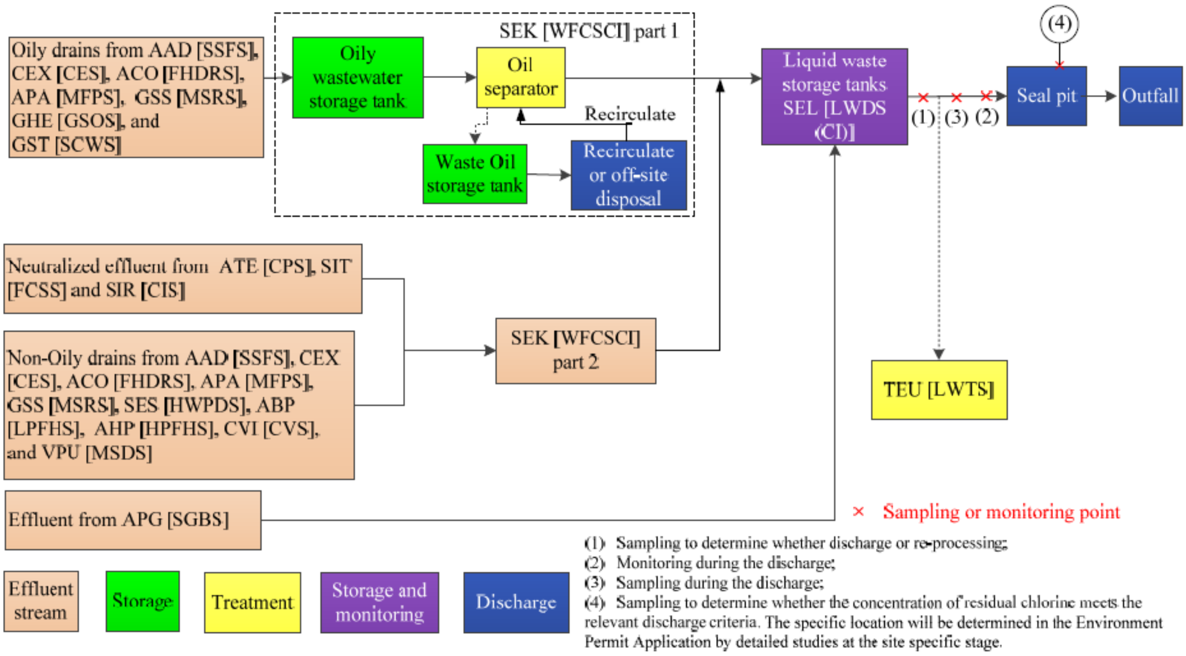

Figure 14-2: GNSL flow diagram for potentially radioactive effluent streams (GNSL, 2020f)

GNSL developed a structured process to identify all chemicals that are likely be in used in the UK HPR1000 design, to identify the route each substance will take through the plant and then to calculate discharge estimates in terms of an average and maximum annual load (in kg). These estimates were then used for the environmental impact assessment (see 'environmental impact assessment' below). This chemical emission inventory (GNSL, 2019b) covered the routes shown in Figures 14-1 and 14-2 above and the cooling water system. The estimates were developed by using OPEX from similar operational nuclear power stations.

The discharge estimates obtained for the UK HPR1000 were then compared with French and Chinese fleets as well as the UK European pressurised reactor (UK EPR) design data. The results for all chemicals assessed (apart from hydrazine) show that discharges are comparable to the Chinese and French fleets and the UK EPR. GNSL explained that this could be due to the assumption at GDA that hydrazine will not be treated before discharge, whereas it is in the French fleet and UK EPR. GNSL considered that a future operator could reduce the discharge estimates for hydrazine at the site-specific stage by applying treatment techniques. We asked GNSL for more information on this in RQ-UKHPR1000-0823, which remains open at the time of writing. In order to ensure this is highlighted as an outcome from GDA, we have raised the following Assessment Finding, which also ensures refinement of the chemical emissions inventory at the site-specific stage:

Assessment Finding 34: A future operator shall review the calculations for emissions of chemicals as part of the site-specific environmental risk assessment. Particular attention should be focussed on the application of possible treatment techniques for hydrazine to reduce the amount discharged to the environment, and therefore minimise any impact.

Subject to the assessment finding above (and the outcome of RQ-UKHPR1000-0823), we are content with GNSL's conclusions for this aspect of the design.

Effluents associated with non-radioactive waste streams

There are 3 effluent management systems for non-radioactive waste streams in the UK HPR1000 design:

- station sewer system (SSS) Part 1
- station sewer system (SSS) Part 2
- waste oil and non-radioactive water drainage system (WONWDS)

These 3 systems have been classed as out of scope of GDA but GNSL has provided some basic information on each in its ‘Pre-Construction Environmental Safety Report (PCER) on Conventional Impact Assessment' (GNSL, 2020f).

The station sewer system part 1 accepts effluents from the non-radioactive parts of the nuclear island (for example, air conditioning systems and ventilation systems) as well as domestic sewage from a number of buildings.

The station sewer system part 2 collects site surface rainwater, roof water and uncontaminated waster released from the circulating water system among other non-radioactive systems.

The waste oil and non-radioactive water drainage system collects all the non-radioactive oily water from various sources.

These 3 systems are out of scope of GDA and can all be independently discharged directly into the environment. It is essential that a future operator focuses on the site-specific design of these systems as this has not been addressed at GDA. We, therefore, consider the following Assessment Finding to be appropriate:

Assessment Finding 35: A future operator shall ensure that the storage, treatment and monitoring systems for the 3 non-radioactive effluent streams provide the appropriate level of environmental protection for the receiving environment in terms of quality of effluent discharged. This would be regulated by a water discharge activity permit.

We are unable to provide any definitive conclusions on this aspect of the design as it is out of scope of GDA and the majority of the decision making has been left to the site-specific stage.

Effluents associated with cooling water systems

The cooling water system comprises 3 systems: the circulating water system, essential service water system and the auxiliary cooling water system. These systems are described in section 13 above in the context of water abstraction and use. When the water has been used to cool the various components of the design, because a once-through system is proposed, it will need to be discharged back into the environment under the terms of a water discharge activity permit. This assessment is based on the once-through cooling water system proposed by the RP for GDA. If an alternative cooling water technique is chosen at the site-specific stage, then this will need to be reassessed at that time.

In order to prevent biofouling of the internal systems, the abstracted cooling water is dosed with a biocide. GNSL considers the final choice of biocide to be a site-specific matter for a future operator to decide. For the purposes of GDA, sodium hypochlorite has been assumed and a residual chlorine target for the final discharge is in the range of 0.1mg/l - 0.5 mg/l, with a daily average of 0.2mg/l. These details have been carried forward to the environmental impact assessment (see 'environmental impact assessment' below).

The thermal impact of the cooling water discharge is considered to be highly site-specific and has therefore been agreed as out of scope of this GDA. GNSL has calculated that the temperature of discharges from the site will be approximately 9.7^{o}C higher than when abstracted.

In common with similar types of power stations, there is no treatment of the cooling water prior to discharge. The 3 cooling water systems are directed to the seal pit where some mixing with the effluents associated with radioactive waste streams will occur as it discharges to the environment via the main site outfall.

Environmental impact assessment

Despite much of the above section leaving options open for a future operator to make at site-specific design stage, we asked the RP to consider the environmental impact of water discharges at GDA stage.

We asked the RP to provide an environmental impact assessment at GDA stage to determine whether the proposed emissions from the generic design could be considered potentially acceptable at the site-specific stage. The impact assessment is necessarily generic at this stage because there are a number of aspects of the use and treatment of chemicals that are not known at GDA stage and the specific environmental setting is also not known. Both of these elements will need to be included in more detailed site-specific modelling for the application for a water discharge activity permit. To ensure this aspect is addressed, we raise the following Assessment Finding:

Assessment Finding 36: A future operator shall provide in an application for a water discharge activity environmental permit a site-specific environmental impact assessment for discharges to water. The modelling shall use site-specific parameters based on the environmental setting and the specific chemicals selected for use.

The environmental impact assessment carried out for GDA was an initial screening assessment using our recommended H1 tool environmental risk assessment tool.

GNSL followed the series of tests as specified in our H1 guidance (our guidance can be found at https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit). We are satisfied that our approach was followed correctly for this impact assessment. The initial test compares the discharge concentration with the corresponding Environmental Quality Standard (EQS). The discharge concentration is the concentration at the end of the pipe before the effluent enters the environment (that is, no further dilution). If the discharge concentration is lower than the corresponding EQS, then the substance is screened out from further assessment. The EQSs used by GNSL in its assessment were for 'estuaries or coastal waters' so they are appropriate for the generic site proposed in this GDA.

The following substances were assessed:

- boron
- lithium hydroxide
- ammonia
- hydrazine
- chlorine (as TRO)
- copper (dissolved)
- iron
- nickel (dissolved)

- lead (dissolved)
- zinc (total)

All of the above substances were screened out after the initial test except chlorine and hydrazine which were subjected to further tests.

The next test involves comparing the effective volume flux (EVF) with the allowable effective volume flux (AEVF) for buoyant discharges such as this, as described in our guidance. (https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit). Chlorine was screened out from needing further assessment at this stage.

Hydrazine did not screen out and, as such, remains a substance that warrants particular attention at the site-specific stage. This has been acknowledged by GNSL's Pre-Construction Environmental Safety Report (PCER) on Conventional Impact Assessment' (GNSL, 2020f). If the H1 tool had produced this outcome when being used at a site-specific permitting stage, then we would require the operator to carry out more detailed modelling of the specific discharge in the specific environment. We do not consider it appropriate to ask for this at GDA stage, as there would be so many assumptions that the outcomes would have a high level of uncertainty associated with them.

The risk assessment carried out by GNSL is sufficient for GDA, but a future operator will have to carry out a site-specific assessment as part of the permit application. This will ensure that the assessment is carried out with site-specific environmental information on the receiving environment and with a much lower level of assumption and uncertainty in the input parameters. We consider the following Assessment Finding (that was introduced above) appropriate to ensure this happens:

Assessment Finding 36: A future operator shall provide in an application for a water discharge activity environmental permit a site-specific environmental impact assessment for discharges to water. The modelling shall use site-specific parameters based on the environmental setting and the specific chemicals selected for use.

As part of the site-specific permit application, the operator will also need to consider whether there are any designated habitat sites (including Sites of Special Scientific Interest, Marine Conservation Zones, Special Protection Areas, Special Areas of Conservation or Ramsar sites) in the area and, if necessary, carry out a Habitats Regulations assessment.

Options for beneficial use of waste heat

A nuclear power station, like other thermal power generation processes, converts thermal energy into electrical power. It is not possible to convert 100% of the thermal energy into electricity, therefore, there is residual heat in the cooling water that is released to the environment. In our P&ID we ask the RP to consider possible uses of the waste heat that would be compatible with the design.

GNSL considers that the potential for beneficial use of waste heat is a highly site-specific matter because it depends on what potential users are situated nearby. GNSL has identified a number of possible uses of waste heat in the agricultural, industrial and civic sectors.

Discharges to groundwater

Information on discharges to groundwater is provided in GNSL's Pre-Construction Environmental Safety Report (PCER) on Conventional Impact Assessment' (GNSL, 2020f). In this document, GNSL confirms that there that there are no intentional discharges to groundwater.

The measures taken in the UK HPR1000 design to prevent and minimise unintentional discharges to groundwater are described in the ‘Pre-Construction Environmental Safety Report (PCER) on Conventional Impact Assessment' (GNSL, 2020f).

GNSL states that the site infrastructure will be designed to prevent the release of contaminated water to soil and groundwater. This will be based on site-specific credible accident scenarios and will be in line with relevant guidance and legislation. The design requirements will include, but not be limited to:

- primary containment design (tanks)
- secondary containment design (bunds)
- tertiary containment systems (hardstanding linked to the drainage systems)
- firewater containment systems

GNSL states that the following measures will also be implemented:

- provision of spill kits
- management arrangements, including staff training (deliveries, spill prevention and response)

The detailed site layout design can only be determined at the site-specific stage, therefore the exact arrangements for drainage, bunding (secondary containment) and tertiary containment are not known at GDA.

We accept, for the purposes of GDA, that these measures are relevant good practice and expect these to be incorporated into the management system and implemented before operations begin on any specific site.

We regulate these types of environmental protection systems under a number of regimes (EPR, COMAH, pollution prevention advice), so we will be able to ensure they are implemented properly at the site-specific stage.

Our overall preliminary conclusion on discharges to surface waters and groundwater

Following our assessment of the surface water discharges, our preliminary conclusions are that:

- the UK HPR1000 will have non-radioactive discharges to surface water and will require an environmental permit for a water discharge activity
- the information GNSL provided for GDA is sufficient for us to conclude that the impact from discharges to surface waters could be at levels low enough to enable a reasonable application for a water discharge activity permit. However, the risk assessment work carried out for GDA must be revised with greater detail at the site-specific permitting stage to reduce the level of uncertainty that exists in the work carried out to date. At the site-specific stage all necessary permissions must be applied for and obtained by the future operator.

Following our assessment of discharges to groundwater, our preliminary conclusions are that:

- there should be no intentional discharges to groundwater, and an environmental permit for a groundwater activity will not be required
- the UK HPR1000 should have appropriate measures in place to prevent pollution of the land or groundwater

We have identified no potential GDA Issues and 3 Assessment Findings, as set out in the above paragraphs and at the beginning of this chapter.

More details of our assessment of discharges to surface waters and groundwater can be found in our assessment report AR08 (Environment Agency, 2021h).

15. Operation of installations

This chapter covers our assessment of installations (as defined in Schedule 1 to EPR16). Most nuclear power station designs include conventional combustion plant of sufficient capacity to require permitting for standby generation and/or use as auxiliary boilers. Other ancillary plant may also meet a description in Schedule 1 to EPR16 and require permitting.

Our preliminary conclusions are that:

- the UK HPR1000 combustion plant (diesel generators) is likely to be a Part A(1) installation as described in section 1.1 of chapter 1 in part 2 of Schedule 1 of the Environmental Permitting (England and Wales) Regulations 2016 and will, therefore, require an environmental permit from the Environment Agency
- several aspects of the GDA submission will need to be revised and updated when site-specific data are available. The main aspects that will need considering further are:
    - a BAT assessment for the chosen diesel generators
    - the application of medium combustion plant legislative requirements. This may require the necessary monitoring infrastructure to be included in the design (that is, in line with technical guidance note M1 (Environment Agency, 2017b))
    - site-specific modelling to demonstrate compliance with air quality objectives
    - the UK HPR1000 combustion plant will also require a permit under the Greenhouse Gas Emissions Trading Scheme Regulations 2012 (GGETSR12) (GB Parliament, 2012)

We have identified no potential GDA Issues and 2 Assessment Findings.

Assessment Finding 37: A future operator shall provide in an application for an environmental permit a BAT assessment of the specific combustion plant selected for use against the relevant BAT guidance at the time of application.

Assessment Finding 38: A future operator shall provide in an application for a combustion activity environmental permit a site-specific environmental impact assessment for discharges to air. The modelling shall use site-specific parameters based on the environmental setting and the specific combustion plant selected for use.

We want to ask you:

Consultation question 11:

Do you have any views or comments on our preliminary conclusions on the operation of installations?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Identifying installations

Information on the operation of installations is provided in GNSL's 'Pre-Construction Environmental Safety Report (PCER) on Conventional Impact Assessment' (GNSL, 2020f).

Combustion plant

The conventional combustion plant is specified in GNSL's 'Pre-Construction Environmental Safety Report (PCER) on Conventional Impact Assessment' (GNSL, 2020f). It will consist of:

- 3 fixed emergency diesel generators (EDGs), each with a thermal input of 19.45MW to supply 8MWe of electricity
- 2 fixed station blackout diesel generators (SBO DGs), each with a thermal input of 8.27MW to supply 3.1MWe of electricity
- one smaller Emergency Security DG (ESDG) with a rated thermal input of 0.82MWth to supply 0.32MWe of electricity
- one smaller diesel generator (DG) with a rated thermal input of 0.82MWth to supply 0.32MWe of electricity

We expect this list to be refined as GDA progresses and this area will be re-visited in the final assessment report. We do not expect any potential changes to affect the environmental impact assessment carried out by GNSL and assessed here.

GNSL has considered the 2 smaller generators as out of scope of GDA and due to their relatively small size and we agree with this conclusion. The following assessment applies to the 3 EDGs and 2 SBO DGs.

As the total thermal input of the combustion plant exceeds 50MWth, it is a Part A(1) installation as described in section 1.1 of chapter 1 in part 2 of Schedule 1 in EPR16. This means that it will require an environmental permit from the Environment Agency.

As the total thermal input exceeds 20MWth, the combustion plant is also a 'regulated activity' as defined in GGETSR12 and will require a greenhouse gas emissions permit under those regulations (GB Parliament, 2012).

Other ancillary plant

In general, the only other ancillary plant found on a nuclear power station that might need a permit under EPR16 would be any on-site waste incinerator. The submission confirms in the 'Pre-Construction Environmental Safety Report (PCER) on Conventional Impact Assessment' (GNSL, 2020f) that the design does not include an on-site incinerator.

Combustion plant operations

The 3 EDGs are classed as nuclear safety equipment. They are included in the design to provide emergency power to the equipment related to the safe shutdown of the reactor in the event of a loss of off-site power supply. The EDGs are required to start up quickly and automatically in the event of a loss of off-site power.

The 2 SBO DGs are also classed as nuclear safety equipment. They are included in the design to provide power to nuclear safety related equipment in the event of a station black-out condition (loss of off-site and on-site power).

GNSL describes the 3 operating conditions of the EDGs and the SBO DGs as commissioning, periodic testing and operational (in the event of a loss of power). These 3 plant conditions have been carried through to the environmental impact assessment (see below).

GNSL states that the final selection of the combustion plant will be carried out at the site-specific stage. This will be based on a review of suitable combustion plant available and the selection will be based on the assessment of BAT.

At the time of writing, we are aware that work is ongoing to address some uncertainty over the power requirements of security arrangements, some safety related aspects may change the capacity of the generators and the power requirements of the HVAC system. We will continue to assess any design changes that occur between consultation and the end of GDA to ensure the generic environmental impact assessments are amended accordingly, if necessary.

In accordance with our P&ID requirements, GNSL carried out a high-level comparison of the proposed combustion technology against the Environment Agency Combustion Sector Guidance Note (Environment Agency, 2009) and relevant Environment Agency guidance on controlling and monitoring emissions for an environmental permit (Environment Agency, 2020b). The combustion sector note was withdrawn during the course of this GDA (on 24 August 2018), but due to the high-level nature of the assessment at GDA stage the comparison still stands. A future operator will need to carry out a more detailed BAT assessment at the site-specific permitting stage, so we consider the following Assessment Finding to be appropriate:

Assessment Finding 37: A future operator shall provide in an application for an environmental permit a BAT assessment of the specific combustion plant selected for use against the relevant BAT guidance at the time of application.

The BAT assessment GNSL provided for this GDA covers all the relevant topic areas we would expect to see for a proposed combustion plant, which include:

– energy efficiency
– avoiding, recovering and disposing of wastes
– operational issues
– point source emissions to water
– point source emissions to air
– fugitive emissions
– monitoring

Overall, acknowledging the generic nature of any BAT assessment carried out at GDA stage, which is mainly due to the specific plant and environmental setting of the site being unknown, we consider the assessment GNSL has included in its submission to be acceptable.

Environmental impact assessment

We asked the RP to provide an environmental impact assessment at GDA stage to determine whether the proposed emissions from the generic design can be considered reasonable at the site-specific stage. The impact assessment is generic at this stage because the specific combustion plant and the specific environmental setting are not known. Both of these elements will need to be included in more detailed site-specific modelling to support an application for an installation activity environmental permit. To ensure this aspect is addressed, we raised the following Assessment Finding:

Assessment Finding 38: A future operator shall provide in an application for a combustion activity environmental permit a site-specific environmental impact assessment for discharges to air. The modelling shall use site-specific parameters based on the environmental setting and the specific combustion plant selected for use.

The environmental impact assessment carried out for GDA involved an initial screening assessment using our recommended H1 tool. The purpose of the initial screening assessment was to assess the ground level concentrations of the combustion plant emissions against the applicable relevant short-term and long-term air quality standards. The assessment was based on the operation of a single EDG or SBO DG operating separately. This is considered acceptable because the assessment only applies to commissioning and testing, which are both operational conditions defined above.

The initial screening assessment compared modelled emissions against human health benchmarks (for NO_2, SO_2, CO, PM_{10} & $PM_{2.5}$) and ecological benchmarks (for NO_2 and SO_2).

The outputs of the modelling for the EDGs showed NO_2 as exceeding the relevant environmental assessment levels (EALs) in the long-term assessment and NO_2, SO_2, CO & PM_{10} exceeding the relevant EALs in the short-term assessment. For the SBO DGs, only the relevant short-term EALs were exceeded for NO_2, SO_2, CO & PM_{10}. Particularly notable results were the modelled short-term NO_2 emissions for the ecological EALs, which were significantly higher than the benchmark for both EDGs and SBO DGs. Although these results could have initially been a cause for concern, it is important to note that the H1 tool used here is extremely conservative in order to apply a high level of protection to the environment.

At site-specific permitting stage, we would normally go on to require an applicant to carry out more detailed modelling using a more in-depth air dispersion model (for example, AERMOD or ADMS). This is very hard to do at GDA stage because the detailed models require a lot of information on the site and environmental setting that the emission point is situated in. The necessary level of detail is simply not available at GDA stage. As an alternative, we asked the RP to carry out a sensitivity analysis to better understand the conservativeness of the H1 tool and whether more acceptable ground level concentrations could be achievable at site-specific stage.

The sensitivity analysis the RP carried out was based on published Environment Agency guidance, which states that a sensitivity analysis should be based on:

- meteorology data
- emission parameters (for example, stack height)
- receptor grid resolution
- treatment of terrain and buildings

The detailed sensitivity analysis is summarised in GNSL's ‘Pre-Construction Environmental Safety Report (PCER) on Conventional Impact Assessment' (GNSL, 2020f). The RP chose to focus on the highest results from the H1 assessment, which were outlined above as 'particularly notable' (short-term ecological assessment for NO_2). The outcome of the sensitivity analysis found that the parameters that are most sensitive (that is, those that affect the results the most) are stack height, meteorology and buildings. The results show that a stack height of 28m would bring the ground level concentrations of NO_2 at the site boundary below the relevant EALs for both the EDGs and the SBO DGs. For the EDGs, the modelled stack height had to be increased to 40m in order to bring the on-site ground level emissions below the relevant EAL. These stack heights are not unrealistic on a nuclear site. These conclusions are underpinned by the detailed analysis assessment presented by the RP in a supporting document entitled 'Environmental Risk Assessment on Air Emission' (GNSL, 2019d).

The decision on final stack heights for the combustion plant is a site-specific issue for a future operator. It is also acknowledged that the final plant layout and further detailed dispersion modelling may reduce the final stack height needed. The purpose of the screening assessment and sensitivity analysis was to demonstrate that the impact of emissions from the combustion plant on the UK HPR1000 could be realistically reduced to acceptable levels to potentially allow a permit to be issued.

The operator will have to carry out site-specific air dispersion modelling as part of the permit application to demonstrate compliance with air quality standards and to demonstrate that the environmental impact from the combustion plant installation is acceptable. We consider the following Assessment Finding appropriate to ensure this happens:

Assessment Finding 38: A future operator shall provide in an application for a combustion activity environmental permit a site-specific environmental impact assessment for discharges to air. The modelling shall use site-specific parameters based on the environmental setting and the specific combustion plant selected for use.

As part of the site-specific permit application, the operator will also need to consider whether there are any designated habitat sites (including Sites of Special Scientific Interest, Marine Conservation Zones, Special Protection Areas, Special Areas of Conservation or Ramsar Convention sites) in the area and, if necessary, carry out a Habitats Regulations assessment.

Medium combustion plant

The Medium Combustion Plant Directive (MCPD) (EU, 2015) is not currently considered in our P&ID because it is a relatively new piece of legislation. We raised this with the RP and asked it to consider how MCPD would apply to its proposed generators.

MCPD applies to all combustion plant between 1 and 50MW so all the generators will be medium combustion plant. They will need to be permitted as such and this is likely to be as part of the installation environmental permit. The legislation does provide a threshold of 500 hours a year under which the emission limits do not apply - but the permit will still include monitoring requirements for important parameters (for example, carbon monoxide and oxides of nitrogen). This will mean that suitable monitoring infrastructure will need to be designed into each generator to enable safe and accurate monitoring to be carried out.

Combustion plant - greenhouse gas emissions

We can only issue a greenhouse gas permit if there are acceptable proposals for monitoring the greenhouse gas emissions.

The UK HPR1000 combustion plant will require a permit from us under the Greenhouse Gas Emission Trading Scheme Regulations 2012 (GB Parliament, 2012) as the total aggregated thermal input is greater than the 20MW threshold set out in those regulations.

GNSL states that the proposed approach to monitoring greenhouse gas emissions will meet the requirements contained in ‘General guidance for installations (Monitoring and Reporting Regulation Guidance Document number 1)’ (EU, 2012b), which provides guidance on how to meet the requirements of the Monitoring and Reporting Regulation for Greenhouse Gas Emissions (EU, 2012a). GNSL states that it will follow the standard method used for calculating emissions as outlined in the relevant guidance document (EU, 2012b). The standard method involves measuring fuel and process inputs and applying appropriate emission, process and oxidation factors to calculate the total emissions.

We accept, for the purposes of GDA, that GNSL has provided sufficient information on greenhouse gas monitoring.

We will continue to assess this aspect as part of our site-specific regulatory activities.

Our overall preliminary conclusion on operation of installations

Our preliminary conclusions are that:

- the UK HPR1000 combustion plant (diesel generators) is likely to be a Part A(1) installation as described in section 1.1 of chapter 1 in part 2 of Schedule 1 of The Environmental Permitting (England and Wales) Regulations 2016 and will, therefore, require an environmental permit from the Environment Agency
- several aspects of the GDA submission will need to be revised and updated when site-specific data are available to enable us to carry out a full determination of an environmental permit application. The main aspects that will need considering further are:
    - a BAT assessment for the chosen diesel generators
    - the application of medium combustion plant legislative requirements. This may require the necessary monitoring infrastructure to be included in the design (that is, in line with technical guidance note M1 (Environment Agency, 2017b))
    - site-specific modelling to demonstrate compliance with air quality objectives
    - the UK HPR1000 combustion plant will also require a permit under the Greenhouse Gas Emissions Trading Scheme Regulations 2012 (GB Parliament, 2012)

We have identified no potential GDA Issues and 2 Assessment Findings, as set out in the above paragraphs and at the beginning of this chapter.

More details of our assessment of operation of installations can be found in our assessment report AR08 (Environment Agency, 2021h).

16. Control of major accident hazards

This chapter covers our assessment of the applicability and requirements of the Control of Major Accident Hazards Regulations (COMAH15) (GB Parliament, 2015a) for the UK HPR1000 design. Nuclear power stations may need to store one or more dangerous substances (as defined in COMAH15) in quantities at which the regulations apply, in which case, precautions to prevent a major accident to the environment need to be considered.

Our preliminary conclusions are that:

- the UK HPR1000 will not be subject to the COMAH Regulations
- changes in inventory at the site-specific stage need to be kept under review to ensure a relevant threshold for the COMAH regulations isn't exceeded. If any of the generic design assumptions change at a site-specific stage, then this preliminary conclusion will need to be reconsidered

We have identified no potential GDA Issues and one Assessment Finding.

Assessment Finding 39: Based on the information presented at GDA, the UK HPR1000 will not be a COMAH establishment during commissioning or operational phases. A future operator shall keep the proposed chemical inventories under review so any applicability of COMAH can be identified early and the necessary major accident prevention measures can be installed.

We want to ask you:

Consultation question 12:

Do you have any views or comments on our preliminary conclusions on the control of major accident hazards?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Dangerous substances

It is worth noting an important aspect of GNSL's COMAH15 assessment. The GDA scope considers a single unit, but in order for the COMAH15 assessment to be more meaningful, GNSL agreed at an early stage in the GDA process to consider 2 units for the assessment. Under COMAH15, qualifying quantities of dangerous substances need to be exceeded in order for the regulations to apply. Considering 2 units at GDA stage ensures that any design modifications required to comply with COMAH15 are not missed by assessing one unit in isolation. We welcome this approach to the COMAH15 assessment.

GNSL developed a process to assess each chemical for the applicability of COMAH15. The process can be summarised as follows:

- step 1 - develop an inventory of chemicals
- step 2 - classify the dangerous substances according to the Classification, Labelling and Packaging Regulation (EU, 2008a) and identify the corresponding qualifying thresholds in the COMAH15 Regulations

- step 3 - carry out the comparison against upper and lower tier thresholds provided in the COMAH15 Regulations. The COMAH15 regulations are set out in such a way that a site (or 'establishment' as defined by the regulations) can be classed as either upper tier or lower tier depending on the quantities of dangerous substances present
- step 4 - application of the 'aggregation rule' and '2% rule'. Both of these rules are provided by the COMAH15 Regulations

We consider GNSL's approach to be appropriate.

The chemical inventory was developed using OPEX from similar operational plants. GNSL has presented an inventory of chemicals with corresponding concentrations, how each will be used and the maximum storage quantities. Two separate inventories have been presented, one for commissioning and one for the operational phases of the plant's life cycle.

The inventories were then used to carry out a range of assessments to cover 3 different scenarios:

- 2 units under commissioning
- one unit under commissioning and one unit in operation
- 2 units in operation

We consider this scenario-based approach to be acceptable as it should ensure that the expected changes in the inventory during the early phases of plant life are considered in this assessment.

The aggregation rule must be applied when no individual dangerous substance is present in a quantity above or equal to a qualifying threshold. The aggregation rule ensures that substances with similar hazards associated with them (health, physical or environmental hazards) are added together. This determines whether the establishment as a whole contains sufficient quantities of dangerous substances for the COMAH15 Regulations to apply. Our assessment found that GNSL had applied the aggregation rule correctly.

The 2% states that any dangerous substance present in quantities less than 2% of the appropriate threshold (identified in step 2 above) can be excluded from the COMAH15 assessment as long as its location prevents it from initiating a major accident. Because the location of each dangerous substance is not known at GDA, the 2% rule could not be applied at this stage. The assessment is therefore applied to the whole of the proposed inventory.

Having followed the procedure outlined above, GNSL concludes that the UK HPR1000 will not be subject to COMAH15 Regulations during the commissioning and operational phases of the plant's life cycle. Construction and decommissioning phases have been agreed as being out of scope of GDA.

We can accept GNSL's findings based on the level of detail known at GDA stage. It is, however, important to note that as a site-specific design develops, the proposed chemical inventory may change. We therefore consider the following Assessment Finding to be appropriate:

Assessment Finding 39: Based on the information presented at GDA, the UK HPR1000 will not be a COMAH establishment during commissioning or operational phases. A future operator shall keep the proposed chemical inventories under

review so any applicability of COMAH can be identified early and the necessary major accident prevention measures can be installed.

Measures to prevent a major accident to the environment

Despite the outcome of the assessment being that the UK HPR1000 will not be subject to the COMAH15 Regulations, GNSL has fulfilled the P&ID requirement to describe the measures it could use to prevent a major accident to the environment (MATTE) should the inventory (and therefore COMAH15 assessment) change at the site-specific stage. We welcome this approach as it ensures that future detailed design and layout of the site considers COMAH.

The measures that could be used are summarised in the 'Pre-Construction Environmental Report on Conventional Impact Assessment' (GNSL, 2020f) and include the main aspects of primary (tanks and pipework), secondary (bunds) and tertiary (kerbed hardstanding and drainage systems) containment systems.

The level of detail GNSL presented in its submission is considered sufficient to demonstrate an awareness at the GDA stage.

Our overall preliminary conclusion on substances subject to the control of major accident hazards

Our preliminary conclusions are that:

- the UK HPR1000 does not involve storing dangerous substances in quantities that exceed the COMAH15 thresholds
- changes in inventory at the site-specific stage need to be kept under review to ensure a relevant threshold for the COMAH regulations isn't exceeded. If any of the generic design assumptions change at a site-specific stage, then this preliminary conclusion will need to be reconsidered

We have identified no potential GDA Issues and one Assessment Finding, as set out in the above paragraphs and at the beginning of this chapter.

More details of our assessment of the control of major accident hazards can be found in our assessment report AR08 (Environment Agency, 2021h).

It should be noted that the above preliminary conclusion relates only to major accidents to the environment. Our partner in the competent authority for COMAH15 regulation, ONR, is responsible for assessing matters relating to impacts on people.

17. Fluorinated greenhouse gases and ozone-depleting substances

This chapter covers our assessment of the use of fluorinated greenhouse gases (F-gases) and ozone-depleting substances in the UK HPR1000. These gases can be used in systems such as those that provide cooling or fire protection. The gases that will be used in the UK HPR1000 are identified, then the measures taken to prevent and minimise leakage are considered.

Our preliminary conclusions are that:

- no ozone-depleting substances are proposed to be used in the design
- the proposed quantities of specific fluorinated greenhouse gases to be used in the design are currently acceptable under the Fluorinated Greenhouse Gas Regulations 2015 (GB Parliament, 2015b) and in common with current UK practice
- the level of detail in the proposed measures to prevent and minimise leakage is considered acceptable for GDA

We have identified no potential GDA Issues and one Assessment Finding.

Assessment Finding 40: A future operator shall keep the fluorinated greenhouse gases proposed for use in the UK HPR1000 under review to ensure they continue to be legally acceptable for use.

We want to ask you:

Consultation question 13:

Do you have any views or comments on our preliminary conclusions on the measures to prevent and minimise leakage of fluorinated greenhouse gases and ozone-depleting substances?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Fluorinated greenhouse gases

A number of F-gases are currently proposed to be used in the UK HPR1000 design in the refrigeration system, fire protection system and as insulating gases. These uses are common in other industrial sectors in the UK. GNSL has specified the list of F-gases proposed to be used in the UK HPR1000 and none of them at the quantities proposed are either banned now or are planned to be banned in the near future. They are, however, in a legislatively controlled phase down in use and therefore ultimately, alternatives will need to be sourced. The legislation controlling these gases may, however, change over time. GNSL should keep the proposed F-gases under review to ensure their continued use at the required quantities remains legally possible in the UK. In the Pre-Construction Environmental Report (PCER) submission GNSL acknowledges this and presents some possible alternatives for future use. GNSL concludes that the final choice of F-gases to be used in the UK HPR1000 is a site-specific matter for a future operator. We consider GNSL's proposals and conclusion to be acceptable at GDA stage. In order to ensure the extent of the GDA assessment is carried through into the site-specific stage, we consider the following Assessment Finding to be appropriate:

Assessment Finding 40: A future operator shall keep the fluorinated greenhouse gases proposed for use in the UK HPR1000 under review to ensure they continue to be legally acceptable for use.

Where these gases are included in the design, the RP must describe the measures proposed to prevent and minimise leakage of such substances. GNSL outlines the proposed measures for each proposed use. Despite being at a very high level in the 'Pre-Construction Environmental Report' submission (GNSL, 2020f), it is considered acceptable at GDA stage due to the site-specific nature of such decisions.

Ozone-depleting substances

GNSL confirms in its 'Pre-Construction Environmental Safety Report (PCER) on Conventional Impact Assessment' (GNSL, 2020f) that no ozone depleting substances will be used in the UK HPR1000 design.

Our overall preliminary conclusion on fluorinated greenhouse gases and ozone-depleting substances

Our preliminary conclusions are that:

- no ozone-depleting substances are proposed to be used in the design
- the proposed quantities of specific fluorinated greenhouse gases to be used in the design are currently acceptable under the relevant legislation (GB Parliament, 2015b) and in common with current UK practice
- the level of detail in the proposed measures to prevent and minimise leakage is considered acceptable for GDA

We have identified no potential GDA Issues and one Assessment Finding, as set out in the above paragraphs and at the beginning of this chapter.

More details of our assessment of fluorinated greenhouse gases and ozone-depleting substances can be found in our assessment report AR08 (Environment Agency, 2021h).

18. Our preliminary conclusion

In this document we are presenting our preliminary conclusions so far. We will continue to assess any developments in the submissions from the Requesting Party and will carefully consider all responses to this consultation before making our final conclusions.

On the basis of our work so far, our preliminary conclusion is that, a SoDA could be issued if all potential GDA Issues are resolved and no new potential GDA issues arise before the end of detailed assessment. If not resolved, we could only issue an iSoDA until the GDA Issues were resolved.

On issue of a SoDA it would mean that the design is suitable for use in England, subject to any developer securing all relevant permits, licences and consents. The iSODA or SoDA would be valid only for a site meeting the identified generic site characteristics.

A future operator would also have to address the Assessment Findings of this GDA at an appropriate point in the site development programme.

We want to ask you:

Consultation question 14:

Do you have any views or comments on our preliminary overall conclusion on the acceptability of the design?

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20. Abbreviations

Acronym	Details
AERMOD	Proprietary aerial dispersion model
ADMS	Proprietary aerial dispersion model
AEVF	Allowable effective volume flux
AF	Assessment Finding
ALARA	As low as reasonably achievable
ALARP	As low as reasonably practicable
BAT	Best available techniques
BEIS	Department for Business, Energy and Industrial Strategy
Bq	Becquerel (SI unit of radioactivity)
BNX	Nuclear auxiliary building
BQZ	ILW interim storage facility
BS EN	British (European) standard
BS ISO	British (International) standard
CGN	China General Nuclear Power Corporation
COMAH15	Control of Major Accident Hazards Regulations 2015
CVCS	Chemical volume control system
CVS	Condenser vacuum system
DECC	Department for Energy and Climate Change (superseded by BEIS)
DF	Decontamination factor
DPUR	Dose per unit release
EAL	Environmental assessment limit
EDF	Electricité de France
EDG	Emergency diesel generator
EPR16	Environmental Permitting Regulations 2016
EQS	Environmental quality standard
ERICA	A dose assessment model for wildlife
EU	European Union
EVF	Effective volume flux
FAC	Flow-accelerated corrosion
FCG3	Fangchenggang unit 3
GB	Great Britain
GDA	Generic design assessment

Acronym	Details
GDAI	GDA Issue
GDF	Geological disposal facility
GGETSR12	Greenhouse Gas Emissions Trading Scheme Regulations 2012
GNSL	General Nuclear System Limited
GTRF	Grid to rod fretting
GWTS	Gaseous waste treatment system
HAW	Higher activity waste
HEPA	High efficiency particulate air
HFT	Hot functional test
HLW	High level waste
HPA	Health Protection Agency (now Public Health England)
HTO	Tritiated water
HVAC	Heating ventilation and air conditioning
IAEA	International Atomic Energy Agency
ICIA	In-core instrument assembly
ILW	Intermediate level waste
IRAT	Initial Radiological Assessment Tool
ISO	International Standards Organisation
iSoDA	Interim statement of design acceptability
IWS	Integrated waste strategy
JPO	Joint Programme Office
LAW	Lower activity wastes
LLW	Low level waste
LLWR	Low Level Waste Repository Ltd (UK)
LoC	Letter of compliance
LRWMS	Liquid radioactive waste management system
LRWTS	Liquid radioactive waste treatment system
LWDS(CI)	Convention island liquid waste discharge system
LWTS	Liquid waste treatment system
MATTE	Major accident to the environment
MCERTS	Monitoring certification
MCPD	Medium Combustion Plant Directive
NDA	Nuclear Decommissioning Authority

Acronym	Details
NDAWG	National Dose Assessment Working Group
NFCC	Non-fuel core components
NGO	Non-governmental organisation
NSS	Nuclear sampling system
NVDS	Nuclear island vent and drain system
OECD	Organisation for Economic Co-operation and Development
ONR	Office for Nuclear Regulation
OPEX	Operating experience
OSPAR	Oslo-Paris (Convention)
P&ID	Process and Information Document
PC CREAM 08	Proprietary dose assessment model
PCER	Pre-Construction Environment Report
PCSR	Pre-Construction Safety Report
pH	Hydrogen potential
PRMS	Plant radiation monitoring system
PTR	Spent fuel pool treatment system
PWR	Pressurised water reactor
RCCA	Rod cluster control assemblies
REPs	Radioactive Substances Regulation Environmental Principles
RGP	Relevant good practice
RI	Regulatory Issue
RO	Regulatory Observation
RP	Requesting Party
RPV	Reactor pressure vessel
RQ	Regulatory Query
RWM	Radioactive Waste Management Ltd (UK)
RWMC	Radioactive waste management case
SBO DG	Station blackout diesel generator
SCCA	Stationary core components assemblies
SF	Spent fuel
SFA	Spent fuel assembly
SFAIRP	So far as is reasonably practicable
SFIS	Spent fuel interim store

Acronym	Details
SFP	Spent fuel pool
SG	Steam generator
SGBS	Steam generator blowdown system
SNS	Secondary neutron source
SoDA	Statement of design acceptability
SSC	Structures, systems and components
SSS	Station sewer system
Sv	Sievert (SI unit of dose)
SWTS	Solid waste treatment system
TRO	Total residual oxidant
TSC	Technical support contract
UK	United Kingdom
UK HPR1000	UK version of the Hualong pressurised reactor, HPR1000
VLLW	Very low level waste
WAC	Waste acceptance criteria
WFCS(CI)	Conventional island waste fluid collection system
WRA91	Water Resources Act 1991

Appendix 1 - Draft iSoDA

323_07_SD15 version 3 (August 2017)

Environment Agency

Generic assessment of candidate nuclear power plant designs

Interim statement of design acceptability for the UK HPR1000 design

submitted by

General Nuclear System Limited

The Environment Agency has undertaken a Generic Design Assessment of General Nuclear System Limited's (GNSLs) UK HPR1000, during the period November 2017 to <month> <year>, using the process set out in the document Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs[1].

The findings of our assessment are summarised in the document:

Decision Document for the Generic Design Assessment of GNSLs UK HPR1000[2]

The Environment Agency is satisfied that GNSL has demonstrated the acceptability for environmental permitting of the UK HPR1000 on the generic site, as defined in Schedule 1, subject to the GDA Issues identified in Schedule 2.

This statement is provided as advice to GNSL, under section 37 of the Environment Act 1995. It does not guarantee that any site-specific applications for environmental permits for the UK HPR1000 will be successful.

This statement will remain valid for ten years from the date of issue. This is subject to no significant new information arising during that period which might call into question our assessment of the UK HPR1000.

<name of authorised person>	<date>

Authorised on behalf of the Environment Agency

References

1. Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, Version 3, Environment Agency, October 2016 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/296440/LIT_7998_3e266c.pdf
2. Decision Document for the Generic Design Assessment of GNSLs UK HPR1000, Environment Agency, <month, year>

Schedule 1 – Scope of the GDA

This interim statement of design acceptability refers to the UK HPR1000 as described in the design reference documentation listed in the Master Document Submission List, version <number>, dated <date>.

Schedule 2 – GDA issues

Reference	GDA Issue	Resolution plan
EA-UKHPR1000-01	The Environment Agency and ONR have identified shortfalls across UK HPR1000 safety case documentation in identifying and using operating experience (OPEX). We expect relevant OPEX to be identified and considered to support the development of environmental protection functionality in the design, consistent with applying best available techniques (BAT).	
EA-UKHPR1000-02	GNSL has not yet provided a demonstration that selected options are optimised with respect to environmental protection and safety. We require GNSL to demonstrate that it has considered environmental aspects, alongside safety aspects, in order to achieve a design optimised for both.	
EA-UKHPR1000-03	GNSL has provided environmental justification for choice of high efficiency particulate air filter design. However, further justification must be provided to demonstrate how best available techniques is applied.	
EA-UKHPR1000-04	GNSL is required to provide information in relation to the long-term storage requirements for the spent fuel and to demonstrate that the conceptual design for spent fuel interim store (SFIS) will deliver these requirements.	
EA-UKHPR1000-05	GNSL is required to provide further substantiation of the proposed strategy for the management of in-core instrument assemblies (ICIAs) and if any changes to the strategy is decided, to assess the impact on the disposal of ICIA wastes.	
EA-UKHPR1000-06	GNSL is required to demonstrate that all higher activity waste (HAW) arisings from the UK HPR1000 will be disposable.	

Appendix 2 - Assessment Findings

AF#	Assessment Finding
AF1	The future site operator shall develop arrangements for managing GDA assessment findings, requirements and assumptions relating to environmental aspects of the design.
AF2	If a future site operator has multiple sites, an assessment of BAT should be produced which covers all of its sites, noting the proximity principle, economies of scale and other efficiencies in disposal of solid and incinerable liquid wastes. The assessment should form part of a future operators submissions for its second and subsequent environmental permit applications.
AF3	A future operator shall develop arrangements for managing environment protection measures. This should include manufacturing, commissioning and operation, including examination, maintenance, inspection and testing requirements.
AF4	A future operator shall keep under review the possibility to remove secondary neutron sources or to optimise their design at the earliest occasion.
AF5	A future operator shall demonstrate that the UK HPR1000 will be operated in a way that represents best available techniques for the selection and change strategy of demineraliser resins for liquid waste management systems.
AF6	A future operator shall review and optimise water chemistry regimes presented during GDA to reduce waste generation.
AF7	A future operator shall demonstrate that the dissolved nitrogen level in the primary coolant is minimised.
AF8	A future operator shall review the practicability of techniques for abating carbon-14.
AF9	A future operator shall optimise the balance between gaseous, liquid and solid phase of carbon-14.
AF10	A future operator shall assess the chemical form of carbon-14 discharged to the environment and use this to inform future dose assessments.
AF11	A future operator shall assess the impact of its proposed operating fuel cycle on the radioactive waste generation and disposal before implementing any changes.
AF12	A future operator shall address the post-GDA forward action plans identified by GNSL in the 'Demonstration of BAT' submission, HPR/GDA/PCER/0003, Revision 001-1, October 2020
AF13	A future operator shall keep the headroom factors derived during GDA under review. Operational data generated by the UK HPR1000 should be used to periodically revise the headroom factors to ensure they are minimised as much as possible.

AF#	Assessment Finding
AF14	A future operator shall ensure that its characterisation programme will identify any hazardous materials and non-hazardous pollutants that will be associated with the waste inventory for the UK HPR1000.
AF15	A future operator shall assess whether there are benefits in periodic decontamination of the UK HPR1000 primary circuit and its related systems and auxiliary circuits with regard to minimising production of decommissioning wastes and their classification. The future operator should demonstrate that BAT is being applied.
AF16	A future operator shall ensure that the decommissioning plan is periodically reviewed to ensure that BAT is being applied with regard to decommissioning the UK HPR1000.
AF17	A future operator shall review periodically the options for the treatment and disposal of solid low level waste from the operation and decommissioning of the UK HPR1000. The future operator shall ensure that the options implemented are BAT and will meet the disposal facilities waste acceptance criteria.
AF18	A future operator shall periodically update the Radioactive Waste Management Case or equivalent documentation in accordance with the Environment Agency's and ONR's joint guidance, in order to demonstrate that the higher activity waste is being managed across the whole life cycle. .
AF19	A future operator shall develop its characterisation strategy and approach to segregation for solid and non-aqueous wastes further at the detailed design stage, to ensure that it can demonstrate that BAT is being applied.
AF20	A future operator shall ensure that the proposed conditioning and packaging options for the higher activity wastes for the operational and decommissioning waste arisings from the UK HPR1000 are BAT.
AF21	A future operator shall develop arrangements for identifying and managing non-compliant waste packages, to ensure that only packages that are suitable for disposal will be transferred to a GDF.
AF22	A future operator shall ensure that it deploys BAT for the conditioning of the spent fuel, prior to transferring the spent fuel assemblies to the spent fuel interim store.
AF23	A future operator shall ensure that the monitoring and inspection of the spent fuel assemblies and canister, within the spent fuel interim store are BAT.
AF24	A future operator shall ensure that the strategy for managing failed fuel over the life time of the UK HPR1000 is BAT.
AF25	A future operator shall engage with the operators of the disposal facilities to ensure that their requirements are complied with for both low activity wastes' and higher activity wastes' records.
AF26	A future operator shall continue to secure international OPEX with regard to the dry storage of spent fuels and ensure that it applies learning from the international OPEX to the storage of the UK HPR1000 fuel arisings.
AF27	A future operator shall secure and use OPEX, including that available internationally, to ensure that BAT is used to decommission the UK

AF#	Assessment Finding
	HPR1000 and that the generation of radioactive solid waste is minimised and it is capable of being disposed of.
AF28	A future operator shall address the post-GDA forward action plans identified in the 'Approach to Sampling & Monitoring' submission - HPR/GDA/PCER/0005, Revision 001-1, October 2020.
AF29	A future operator shall demonstrate, before the reactor is commissioned, that the final configuration of the sampling lines and the layout and positioning of the monitoring room are optimised to comply with ISO2889 and the use of best available techniques.
AF30	A future operator shall demonstrate that, before signing of the relevant procurement contracts, the selected sampling and monitoring equipment for determining the discharges are best available techniques and enables the EU recommended levels of detection to be met.
AF31	A future operator shall demonstrate that the systems and equipment used for monitoring and sentencing solid and non-aqueous liquid waste are best available techniques.
AF32	A future operator shall engage with the local water supply company early in the site-specific stage. This is to ensure that sufficient quantities of fresh water can be supplied to meet the requirements of the UK HPR1000 or to determine whether an alternative source of fresh water will need to be identified.
AF33	A future operator shall ensure that the siting of the cooling water intake and outlets are BAT for the UK HPR1000 design at each specific site.
AF34	A future operator shall review the calculations for emissions of chemicals as part of the site-specific environmental risk assessment. Particular attention should be focussed on the application of possible treatment techniques for hydrazine to reduce the amount discharged to the environment, and therefore minimise any impact.
AF35	A future operator shall ensure that the storage, treatment and monitoring systems for the 3 non-radioactive effluent streams provide the appropriate level of environmental protection for the receiving environment in terms of quality of effluent discharged. This would be regulated by a water discharge activity permit.
AF36	A future operator shall provide in an application for a water discharge activity environmental permit a site-specific environmental impact assessment for discharges to water. The modelling shall use site-specific parameters based on the environmental setting and the specific chemicals selected for use.
AF37	A future operator shall provide in an application for an environmental permit a BAT assessment of the specific combustion plant selected for use against the relevant BAT guidance at the time of application.
AF38	A future operator shall provide in an application for a combustion activity environmental permit a site-specific environmental impact assessment for discharges to air. The modelling shall use site-specific parameters based on

AF#	Assessment Finding
	the environmental setting and the specific combustion plant selected for use.
AF39	Based on the information presented at GDA, the UK HPR1000 will not be a COMAH establishment during commissioning or operational phases. A future operator shall keep the proposed chemical inventories under review so any applicability of COMAH can be identified early and the necessary major accident prevention measures can be installed.
AF40	A future operator shall keep the fluorinated greenhouse gases proposed for use in the UK HPR1000 under review to ensure they continue to be legally acceptable for use.

Appendix 3 - Consultation Plan

Generic design assessment of the UK HPR1000: consultation plan

This plan is published on GOV.UK https://www.gov.uk/government/publications/generic-design-assessment-of-the-uk-hpr1000-consultation-plan

Regulators make decisions about the acceptability of nuclear reactor designs.

This plan sets out how the Environment Agency is proposing to consult with stakeholders on the generic design assessment (GDA) of General Nuclear System Ltd's UK HPR1000 nuclear power station.

We want you to tell us what you think about our assessment of the UK HPR1000 to help inform our final decision.

The 12-week consultation begins on 11 January 2021 and will close on 4 April 2021.

The Environment Agency's priority is to protect people and the environment, and to support those we regulate during the coronavirus pandemic. Read our coronavirus update https://www.gov.uk/government/news/coronavirus-environment-agency-update

1. Feedback on our approach

If you have any comments about our approach to consultation of the UK HPR1000, please email:

nuclear@environment-agency.gov.uk

2. Who may be interested in our consultation

Members of the public and other stakeholders who:

- want to give the Environment Agency information that's relevant to the generic design assessment of the UK HPR1000 nuclear power station
- live or work in an area where this design may be proposed by a developer (currently local council areas near the Bradwell nuclear site, Blackwater estuary and the surrounding towns and villages)
- represent a community they will share this information with
- are interested in how we assess new nuclear power stations

3. Approach to engaging

While it will always remain the responsibility of the regulators to make decisions about the assessment of nuclear power station designs, we want our decisions to be better informed through good engagement.

It's important to us that we involve people in decisions that affect their community. We want to understand peoples' comments and views. Where relevant we can use these to help inform our assessments.

We'll publish a document that sets out our preliminary conclusions on the design alongside our assessment reports. We'll consult you on these conclusions in England from January 2021. When the consultation starts we'll add a link to this page so you can respond to the consultation.

We will not make our final decisions on the UK HPR1000 until we have carefully considered comments from the consultation.

4. Engagement aims

Our aim is to strengthen trust and confidence in us as regulators and to make sure:

- we understand stakeholder views so that we can use them to inform our assessments
- we reach a wide range of stakeholders at appropriate times
- our stakeholders understand how they can provide comments and views
- our stakeholders understand our role in nuclear regulation – what we do and what we do not do

5. Consultation objectives

We want to make sure stakeholders:

- understand how we assessed the reactor design
- understand the conclusions of our assessments and why we have made our decisions
- understand how they can provide their views, what they can and cannot comment on and how we'll use their input to inform our assessment
- have many opportunities to give us their views
- help make our final decision on the acceptability of the reactor design as robust as possible
- know more about how GDA fits into the bigger picture of nuclear power station development
- understand each regulator's role, specifically around GDA and regulation of nuclear new build – what we do and what we do not do

6. Our stakeholders

We will consult with:

- members of the public (including local interest and action groups) near existing or proposed nuclear power stations, particularly those living near to Bradwell where the UK HPR1000 is proposed.
- elected representatives and government agencies, including MPs
- local councils, especially those within a 25 mile radius of the proposed Bradwell B power station and other representative bodies near the site
- non-government organisations (NGOs) and environmental groups
- academics
- the nuclear industry, including potential developers and operators

7. Preparing to consult

We've talked to national and local stakeholders about:

- their communities and the local environment
- how they prefer to receive information from us
- events and meetings we can attend to talk about our work
- the best locations to hold community drop-in events
- concerns and opportunities around online engagement

8. How we'll engage and communicate during consultation

We will:

- publish information on GOV.UK
- carry out an online public consultation on Citizen Space
- share information through e-bulletins
- use our social media accounts to raise awareness
- work with journalists to share information in local and national media
- provide information such as leaflets or infographics to the local community
- advertise the consultation in local media
- share information through community channels and local advocates
- share information through General Nuclear System Ltd and Bradwell Generation Company channels (for example a newsletter) where appropriate
- invite national stakeholders to an online consultation event
- offer video and telephone questions and answer sessions
- hold local community drop in events near Bradwell Generation Company's proposed site unless Environment Agency and public health guidance prevents this
- listen to NGO concerns at nuclear liaison fora
- meet with representatives and groups near proposed sites - online or in person, unless Environment Agency and public health guidance prevents this
- participate in conferences, meetings and exhibitions run by others
- attend and speak at site stakeholder groups and community meetings – online or in person, unless Environment Agency and public health guidance prevents this
- brief national and local MPs

9. How to get involved

Please email your comments about this consultation plan to nuclear@environment-agency.gov.uk

10. Responding to stakeholders

We will:

- consider responses we receive and any information arising from the consultation
- use these responses to inform our decisions where relevant
- explain how stakeholder input has informed our decisions
- update stakeholders about stages of the consultation and our final decisions through our websites, e-bulletins, social media and news stories, and at events

We expect to:

- publish a document containing all your responses on GOV.UK in May 2021, approximately 1 month from the close of consultation
- publish our decision document on GOV.UK at the end of GDA – our target to complete this is early 2022

11. Keep in touch

You can sign up to our e-bulletin. Email nuclear@environment-agency.gov.uk.

12. More information

You can read:

– New nuclear power: assessing power station designs https://www.gov.uk/guidance/new-nuclear-power-stations-assessing-reactor-designs
– Generic design assessment of new nuclear power stations http://www.onr.org.uk/new-reactors/index.htm
– about the government's consultation principles https://www.gov.uk/government/publications/consultation-principles-guidance

GDA comments process

General Nuclear System Ltd's comments process is a requirement of our GDA process. The comments process started in November 2017. http://www.ukhpr1000.co.uk/make-a-comment/

Appendix 4 - GNSL's GDA submission documents

The following documents and their supporting references make up the GNSL GDA submission.

Document title	Document number
Pre-Construction Environmental Report Chapter 1: Introduction	HPR/GDA/PCER/001
Pre-Construction Environmental Report Chapter 2: Generic Site Description	HPR/GDA/PCER/002
Pre-Construction Environmental Report Chapter 3: Demonstration of BAT	HPR/GDA/PCER/003
Pre-Construction Environmental Report Chapter 4: Radioactive Waste Management Arrangements	HPR/GDA/PCER/004
Pre-Construction Environmental Report Chapter 5: Approach to Sampling and Monitoring	HPR/GDA/PCER/005
Pre-Construction Environmental Report Chapter 6: Quantification of Discharges and Limits	HPR/GDA/PCER/006
Pre-Construction Environmental Report Chapter 7: Radiological Assessment	HPR/GDA/PCER/007
Pre-Construction Environmental Report Chapter 8: Conventional Impact Assessment	HPR/GDA/PCER/008
Pre-Construction Safety Report Chapter 1: Introduction	HPR/GDA/PCSR/001
Pre-Construction Safety Report Chapter 2: General Plant Description	HPR/GDA/PCSR/002
Pre-Construction Safety Report Chapter 3: Generic Site Characteristics	HPR/GDA/PCSR/003
Pre-Construction Safety Report Chapter 4: General Safety and Design Principles	HPR/GDA/PCSR/004
Pre-Construction Safety Report Chapter 5: Reactor Core	HPR/GDA/PCSR/005
Pre-Construction Safety Report Chapter 6: Reactor Coolant Systems	HPR/GDA/PCSR/006
Pre-Construction Safety Report Chapter 7: Safety Systems	HPR/GDA/PCSR/007
Pre-Construction Safety Report Chapter 8: Instrumentation and Control	HPR/GDA/PCSR/008
Pre-Construction Safety Report Chapter 9: Electric Power	HPR/GDA/PCSR/009

Document title	Document number
Pre-Construction Safety Report Chapter 10: Auxiliary Systems	HPR/GDA/PCSR/010
Pre-Construction Safety Report Chapter 11: Steam and Power Conversion System	HPR/GDA/PCSR/011
Pre-Construction Safety Report Chapter 12: Design Basis Condition Analysis	HPR/GDA/PCSR/012
Pre-Construction Safety Report Chapter 13: Design Extension Conditions and Severe Accident Analysis	HPR/GDA/PCSR/013
Pre-Construction Safety Report Chapter 14: Probabilistic Safety Assessment	HPR/GDA/PCSR/014
Pre-Construction Safety Report Chapter 15: Human Factors	HPR/GDA/PCSR/015
Pre-Construction Safety Report Chapter 16: Civil Works and Structures	HPR/GDA/PCSR/016
Pre-Construction Safety Report Chapter 17: Structural Integrity	HPR/GDA/PCSR/017
Pre-Construction Safety Report Chapter 18: External Hazards	HPR/GDA/PCSR/018
Pre-Construction Safety Report Chapter 19: Internal Hazards	HPR/GDA/PCSR/019
Pre-Construction Safety Report Chapter 20: MSQA and Safety Case Management	HPR/GDA/PCSR/020
Pre-Constriction Safety Report Chapter 21: Reactor Chemistry	HPR/GDA/PCSR/021
Pre-Construction Safety Report Chapter 22: Radiological Protection	HPR/GDA/PCSR/022
Pre-Construction Safety Report Chapter 23: Radioactive Waste Management	HPR/GDA/PCSR/023
Pre-Construction Safety Report Chapter 24: Decommissioning	HPR/GDA/PCSR/024
Pre-Construction Safety Report Chapter 25: Conventional Fire and Safety	HPR/GDA/PCSR/025
Pre-Construction Safety Report Chapter 26: Environment	HPR/GDA/PCSR/026
Pre-Constriction Safety Report Chapter 27: Security	HPR/GDA/PCSR/027
Pre-Construction Safety Report Chapter 28: Fuel Route and Storage	HPR/GDA/PCSR/028
Pre-Construction Safety Report Chapter 29: Interim Storage of Spent Fuel	HPR/GDA/PCSR/029
Pre-Construction Safety Report Chapter 30: Commissioning	HPR/GDA/PCSR/030

Document title	Document number
Pre-Construction Safety Report Chapter 31: Operational Management	HPR/GDA/PCSR/031
Pre-Construction Safety Report Chapter 32: Emergency Preparedness	HPR/GDA/PCSR/032
Pre-Construction Safety Report Chapter 33: ALARP Evaluation	HPR/GDA/PCSR/033
Pre-Construction Safety Report V1 Amendment Report for EA Public Consultation	HPR/GDA/PCSRV1AR/0000

Appendix 5 - Environment Agency Assessment reports

AR#	Assessment report title
AR01	Preliminary detailed assessment of management systems for General Nuclear System Limited's UK HPR1000 design
AR02	Preliminary detailed assessment of strategic considerations for radioactive waste management for General Nuclear System Limited's UK HPR1000 design
AR03	Preliminary detailed assessment of BAT for General Nuclear System Limited's UK HPR1000 design
AR04	Preliminary detailed assessment of gaseous and liquid discharges of radioactive waste for General Nuclear System Limited's UK HPR1000 design
AR05	Preliminary detailed assessment of solid radioactive waste, spent fuel and disposability for General Nuclear System Limited's UK HPR1000 design
AR06	Preliminary detailed assessment of sampling and monitoring for General Nuclear System Limited's UK HPR1000 design
AR07	Preliminary detailed assessment of the generic site description and the assessment of doses to the public and to wildlife for General Nuclear System Limited's UK HPR1000 design
AR08	Preliminary detailed assessment of other environmental regulations for General Nuclear System Limited's UK HPR1000 design
IDA	Independent dose assessment to support the Environment Agency's assessment of the UK HPR1000 GDA

Appendix 6 - Summary of the BAT claims, arguments and evidence GNSL provided

The 'Demonstration of BAT' submission includes 5 claims (noted as sub-claims in the submission) and 24 arguments with associated evidence. We have assessed these and sampled the supporting evidence to reach our preliminary conclusions at this stage.

You can find more details of our assessment of BAT, including a summary of our related RQs and ROs in our report 'Preliminary detailed assessment of BAT for General Nuclear System's UK HPR1000 design ' (AR03) (Environment Agency, 2021c).

Claim 1: Prevent and minimise the creation of radioactive waste and spent fuel

This claim is supported by 7 arguments (1a-1g) and extensive evidence. We summarise each argument below and provide our preliminary conclusions at this time.

Argument 1a: Minimise the concentration of fission products in the primary coolant by the design, manufacture and management of fuel

GNSL recognises that it is important to prevent fission products from leaking out of the fuel into the primary coolant and, in turn, to minimise the radioactive waste production from the treatment and disposal of the primary coolant. GNSL highlights the causes of fuel failure identified by IAEA reports and discusses the likelihood of the causes of fuel failure, for example, grid to rod fretting (GTRF) has historically been the main cause of fuel failure in PWRs worldwide.

The type of fuel assembly specified in GDA is an established fuel design and is used worldwide with substantial OPEX (Societé Francaise d'Energie Nucléaire [SFEN], 1999). Our preliminary conclusion is that the fuel assembly includes the features that will minimise the frequency and severity of fuel failures. We welcome operational specifications being provided for the future operator, which will help to minimise the likelihood of fuel failure.

Argument 1b: Minimise the concentration of fission products in the primary coolant by detecting and managing failed fuel

GNSL provides evidence that the design of the UK HPR1000 allows failed fuel assemblies to be detected and managed to help prevent or minimise fission products from entering the primary coolant.

The nuclear sampling system (NSS) and plant radiation monitoring system (PRMS) provide in-process sampling and monitoring respectively to detect fuel failure during normal operations, including details of the operator response to the 2 alarm levels which will be determined at the site-specific stage.

Evidence is provided for the functions of the on-line and off-line sipping facilities, including the details of the operator response to the gamma activity concentration exceeding the defined threshold.

Our preliminary conclusion is that these systems and facilities will provide an effective process to detect and manage failed fuel in the UK HPR1000 and we welcome a follow up action identified by GNSL.

Argument 1c: Minimise the quantity of spent fuel by core dimension design and cycle length selection

GNSL acknowledges that optimising the efficiency of the UK HPR1000 to reduce the generation of spent fuel minimises the amount of spent fuel that will require management and disposal. The evolution of the UK HPR1000 has resulted in an increase in the core dimensions, which will subsequently result in using more spent fuel assemblies, but improves the thermal energy production per fuel assembly. The widely used 18-month fuel cycle length has been selected, which produces less spent fuel than 12 and 24-month fuel cycles. The future operator has the flexibility to choose a refuelling programme, so we have raised Assessment Finding 11.

Assessment Finding 11: A future site operator shall assess the impact of its proposed operating fuel cycle on the radioactive waste generation and disposal before implementing any changes.

Argument 1d: Minimise the generation of tritium in the primary coolant

GNSL has defined tritium as a significant radionuclide because of the quantity of radioactivity that will be discharged from the UK HPR1000, although the dose to the public and impact on the environment from tritium discharges is low. GNSL recognises that tritium is produced by the fission of heavy nuclei, the neutron activation of primary coolant constituents, such as boron, lithium, deuterium and the neutron activation of specific material constituents, for example, beryllium contained in the secondary neutron source (SNS) rods.

GNSL argues that the large amount of tritium inventory from ternary fission reactions in the fuel is a potential source of tritium in the primary coolant, but the fuel cladding failure of the selected fuel assembly has been significantly minimised, resulting in the very low failure rate of the assembly. The fuel assembly selected for the UK HPR1000 is a widely-used fuel assembly design.

Boric acid is widely used to control reactivity in pressurised water reactors (PWRs). Boric acid enriched with boron-10 is used in the UK HPR1000 to reduce the amount of lithium hydroxide required for pH control. The regulators queried the control of boron (RO-UKHPR1000-0031). The response provided evidence for the systems that control boron addition, dilution, recycling and monitoring and resulted in updates to the 'Topic Report on Power Operation Chemistry'. The response to the RO is in process and the impact on BAT will be monitored.

GNSL acknowledges that lithium hydroxide injected into the primary circuit to adjust the pH of the coolant contributes to tritium production. It argues that tritium production is minimised by using lithium hydroxide with enriched 99.9% lithium-7.

GNSL states that SNS assemblies are used in the UK HPR1000 design to ensure sufficient neutron count for ex-core neutron detectors to monitor the state of the core and ensure criticality control. The SNS assemblies contain beryllium which is a significant source of tritium under neutron radiation. We think it is beneficial to remove them, provided the safety case can be made to do so. GNSL is carrying out a preliminary feasibility assessment to not use SNS assemblies, and states that the future operator will need to keep the option for SNS assembly removal under review. We have identified an Assessment Finding for an evaluation of the environmental impact of removing SNS (Assessment Finding 4).

Assessment Finding 4: A future operator shall keep under review the possibility to remove secondary neutron sources or to optimise their design at the earliest occasion.

We note that relevant ROs raised by ONR remain open at this time, (RO-UKHPR1000-0026, 'Demonstration that radioactivity has been reduced so far as is reasonably practicable' [SFAIRP] and RO-UKHPR1000-0031, 'Control of boron during normal operations and faults') and the outcome are not expected to change the BAT case that the generation of tritium in the primary coolant is minised.

GNSL has provided evidence for minimising the generation of tritium in the primary circuit within the scope of GDA, including proposed controls and limits on the sources of tritium production.

Argument 1e: Minimise the radioactivity level of waste by optimising the water chemistry in the primary coolant

GNSL recognises that primary circuit water chemistry has an important role in protecting equipment and generating radioactive waste during operation, and can influence the waste classifications at decommissioning.

The primary coolant pH is selected in order to obtain minimal corrosion products solubility. The regulator queried the use of the coordinated boron-lithium regime to provide a target pH value of 7.2 for the majority of the cycle (Including RQ-UKHPR1000-0375 and 0487). The responses to the RQs provided additional OPEX and evidence that the target pH of 7.2 is balanced with the lithium concentration to minimise corrosion, and resulted in updates to the 'Topic Report of pH Control in the Primary Circuit of UK HPR1000'.

Hydrogen is added in the primary coolant to maintain a reducing environment which helps to suppress the radiolytic decomposition of water (oxygen source) and dissolved hydrogen concentration control is important in the development of the chemistry programme. The regulators queried the optioneering for the proposed hydrogen concentration and the evidence for choices in developing the chemistry programme (Including RQ-UKHPR1000-0374). The response to the RQ provided further information on how the hydrogen concentration is sustained to maintain a reducing environment and therefore minimise corrosion, and resulted in updates to the 'Topic Report on Hydrogen Dosing Technical Analysis for the Primary Circuit'.

Hydrated hydrazine dosing during plant start-up creates a reducing environment that minimises the generation of corrosion products. Hydrazine injection produces a negligible amount of carbon-14 but this is minor compared to other sources of carbon-14 (Argument 1g). The regulators queried the management of the hydrazine injection (Including RQ-UKHPR1000-0709). The responses to the RQ provided further information, including that the chemical volume control system (CVCS) demineralisers are bypassed when hydrazine is injected to save damaging the resin from the ammonia that is formed and, therefore, reduce radioactive waste.

Low levels of impurities in the primary circuit are maintained by a number of systems that supply the primary coolant makeup water and purify the coolant of the primary circuit so corrosion is minimised. The regulators queried the evidence provided for the justification of the proposed impurity controls levels to minimise corrosion (Including RQ-UKHPR1000-0490). The responses to the RQs discussed the corrosion mechanisms with additional evidence of the controls and resulted in updates to the 'Topic Report on Impurity Control for the Operation'.

GNSL argues that adopting zinc injection is an example of optimising the chemistry regime as it minimises corrosion and subsequent deposition of any corrosion products that are produced. The benefits of adopting zinc injection are reducing the worker dose and for activity levels during decommissioning. Zinc injection can produce carbon-14 in the coolant but this is negligible compared to other sources of carbon-14 (Argument 1g). Zinc injection is regarded as best practice and is adopted as a design modification in the UK HPR1000.

We note that relevant ROs remain open at this time, (RO-UKHPR1000-0015, 'Demonstration that risks associated with fuel deposits are reduced so far as is reasonably practicable [SFAIRP]' and RO-UKHPR1000-0026, 'Demonstration that radioactivity has been reduced so far as Is reasonably practicable [SFAIRP])' Resolving the ROs and the associated submissions are not expected to influence BAT in optimising the water chemistry in the primary circuit to minimise the radioactivity of discharges and waste.

We recognise the development of the primary circuit chemistry regime is a significant aspect in the design and operation of the UK HPR1000, and the design appears to offer flexibility in terms of water chemistry control. We will expect any future operator to ensure optimised water chemistry regimes consistent with the relevant GDA submissions or review them to improve, as this is an important aspect in terms of reducing waste generation. We identify this as Assessment Finding 6.

Assessment Finding 6: A future operator shall review and optimise water chemistry regimes presented during GDA to reduce waste generation.

Argument 1f: Minimise corrosion products generation and activation of structure and component through material selection

GNSL recognises that material selection of structures, systems and components (SSCs) is an important aspect in demonstrating BAT as corrosion and activation of SSCs form radionuclides and consequently contribute to radioactive waste and discharge. GNSL argues that material selection for the UK HPR1000 considers OPEX from the life cycle of worldwide pressurised water reactors (PWRs). It is argued that the amounts of elements which could easily be activated and significantly contribute to waste generation are strictly controlled.

Austenitic stainless steel and alloy 690 are the main materials used in the primary circuit. These materials have corrosion resistance to the primary coolant and the surface finishing will be optimised to decrease corrosion rates and to minimise the production of corrosion products. Austenitic steel and alloy 690 are widely used for primary circuit materials.

The chemistry regime during hot functional testing (HFT) is optimised for important passivation processes to minimise corrosion of the material in the primary circuit. The passivation processes create a protective oxide film which is beneficial in minimising waste. Passivation during hot functional testing is standard practice during commissioning of a nuclear power station (IAEA, 2014).

We recognise minimising the use of certain elements and materials is beneficial in reducing waste, and we will expect a future operator to demonstrate that appropriate choices of materials, including cobalt based alloys, as available at that time, have been selected and procured at the detailed design stage.

Argument 1g: Minimise the production of carbon-14 in the primary coolant

GNSL recognises that carbon-14 is one of the significant radionuclides in terms of the contribution to dose of the most exposed person and discharge activity. GNSL carried out assessments to explore opportunities to minimise the generation of carbon-14. The assessments appropriately focused on generating carbon-14 from the cover and flushing gas.

The regulators queried the control of carbon-14 production (RQ-UKHPR1000-0431) and the RQ response prompted an update to the 'Minimisation of the Discharge and Environment Impact of Carbon-14' submission. The minimisation report provided a balanced benefit and detriment review to conclude that using nitrogen will result in an increase in the generation of carbon-14. This was considered to be outweighed by the safety benefit that would be achieved by eliminating this source of hydrogen and the associate risks of a hydrogen deflagration that would need to be managed using complex safety related control systems.

The carbon-14 minimisation submission (GNSL, 2019e) also highlights that nitrogen is the next best choice after hydrogen as a cover gas. Nitrogen is chemical stable, does not react with water, is non-toxic and non-corrosive, making it a suitable cover gas. Nitrogen does however dissolve in the coolant and nitrogen-14 can be activated to form carbon-14. However, oxygen-17 is the main source of carbon-14 as it contributes to about 88% of the carbon-14 production. This is because the UK HPR1000 uses water as a coolant, in which oxygen-17 is naturally present as one of the isotopes of oxygen and its natural concentration in the coolant is constant. Nitrogen-14 in the primary coolant is the second source of carbon-14 as it contributes to about 12% of the carbon-14 production. Nitrogen is used as a cover gas in existing nuclear power stations. Carbon-14 can be further reduced by using floating barriers in tanks to minimise nitrogen entrainment.

Our preliminary conclusions are that the UK HPR1000 has demonstrated BAT in minimising production of carbon-14. We have raised Assessment Finding 7.

Assessment Finding 7: A future operator shall demonstrate that the dissolved nitrogen level in the primary coolant is minimised.

Claim 2: Minimise the radioactivity of gaseous and aqueous radioactive wastes discharged into the environment

This claim is supported by 7 arguments (2a-2g) and extensive evidence. We summarise each argument below and provide our preliminary conclusions at this time.

Argument 2a: Minimise leaks of radioactive process fluids from containment systems

The design of the UK HPR1000 includes a range of measures to help ensure that radioactive process fluids, that are unavoidably created during operations, are contained within the associated containment systems designated facilities. Relevant measures to ensure leak tightness, as described by GNSL, include the preferential use of welded connections and double isolations, pressure testing, leak detection and collection systems.

The regulators queried the demonstration of BAT for avoiding and minimising underground and embedded liquid containment systems (RQ-UKHPR1000-0745). The response to the RQ confirmed that underground and embedded liquid containment systems are only included in the design where absolutely necessary. Embedded pipework adopts the design of double-layer casing where the outer pipe is in direct contact with concrete and the inner pipe transports the liquid. If the inner pipe leaks it flows towards a sump which can be visually inspected and is monitored.

We consider the measures for ensuring leak tightness as defined by GNSL to demonstrate BAT at the GDA stage.

Argument 2b: Minimise the transfer of radioactivity into the secondary circuit

GNSL recognises that the structural integrity of the steam generators (SGs) is important to minimise the spread of radioactive contamination into the secondary circuit where it has the potential to contaminate downstream SSCs. GNSL also argues that leak tightness from the SG primary side to the secondary side is assured by the design and in-service inspection. GNSL has provided evidence that the materials surfaces in contact with the primary and secondary coolants have been selected to ensure structural integrity and minimise the generation of corrosion productions during the design lifetime. Also, GNSL has provided evidence of the optimisation of the primary and secondary circuit chemistry to minimise corrosion.

We note that the design includes 4 in-process radioactive monitoring techniques provided by the plant radiation monitoring system (PRMS), including noble gases in the main steam line of the main steam system (MSS), nitrogen-16 in the main steam line of the MSS, radioactivity levels in the SG blowdown water via the sampling circuit, and radioactivity levels of non-condensable gas extracted from the condenser vacuum system (CVS) which can detect and alert operators of an issue with the SGs, including a leak from the primary circuit into the secondary circuit. A small leak from the primary circuit into the secondary circuit is included in the expected event list (GNSL, 2019f) with a minor impact on noble gases discharges. In the event of a steam generator tube rupture the main feedwater flow control system (MFFCS) performs SG isolation and main feedwater isolation to avoid SG overfilling, and prevent the radioactive fluid from releasing to the environment.

We endorse that GNSL recommends placing a requirement on the future operator to carry out inspections of the SG during commissioning and at regular intervals throughout its operational lifetime.

We consider the measures for minimising the transfer of radioactivity into the secondary circuit as defined by GNSL to demonstrate BAT as GDA. However, we note the ‘Steam Generator Code Provisions and Mitigation of Relevant Risks' RO (RO-UKHPR1000-0033) is further assessing relevant aspects. We will consider any results as our assessment progresses.

Argument 2c: Minimise the radioactivity of gaseous radioactive waste discharges by optimising the HVAC system

GNSL argues that the heating, ventilation and air conditioning (HVAC) system is designed and configured to abate radioactive particulates using HEPA filters and to abate radioactive isotopes of iodine using iodine adsorbers when iodine is detected to minimise the radioactivity of the gaseous radioactive waste before being discharged to the environment. The HVAC system for the UK HPR1000 is segregated into sub-systems according to the main areas. The regulators queried the management of the HVAC systems to prevent back migration of contamination (RQ-UKHPR1000-0428). The response to the RQ provided evidence that depressions are maintained and the velocity through the containment barrier is maintained greater than 0.5m/s to prevent back flow of air.

The regulators have issued an RO with potential implications for the design of the HVAC system (RO-UKHPR1000-0039). Resolving the RO includes identifying any shortfalls and gaps in the HVAC systems performance and other impacted systems. We will consider any implications arising from resolving this observation when we form our final view.

HEPA filtration within the HVAC systems aims to ensure that the concentration of particulate matter within the gaseous radioactive waste stream is minimised during normal and accident conditions. The extent of filtration, in terms of the number of filter banks, has been designed to ensure appropriate efficiency based on demands from those plant areas. The regulators queried the management of the aerial filtration systems, including the choice of HEPA filter type (RQ-UKHPR1000-0194 and RO-UKHPR1000-0036). The response to the RQ provided evidence for managing condensate that drains into the liquid radioactive waste management system (LRWMS) and supplies air centralised treatment in the nuclear auxiliary building (BNX). Resolving the RO continues and will include providing a robust optioneering study and justification for the choice of HEPA filter type.

The regulators have issued an RO with potential implications for the choice of HEPA filter type (RO-UKHPR1000-0012). Resolving the RO includes carrying out a mechanical engineering relevant good practice (RGP) gap analysis against the design which will include the choice of HEPA filter type. We expect the outcomes of this RO and RO-36 to align.

The iodine adsorbers are bypassed under normal operations and they are brought into operation to reduce radioactive iodine if the PRMS system detects elevated concentrations of radioactivity. The regulators queried the management of the iodine adsorbers (RQ-UKHPR1000-0538). We asked if GNSL had considered if it is BAT to routinely operate with the HVAC iodine adsorbers inline for normal operations that are expected to produce radioactivity or bring the HVAC iodine adsorbers inline. The response to the RQ confirmed that the iodine adsorbers can be brought inline manually by the future operator if particular operations known for producing iodine are planned to be carried out.

Our preliminary conclusion is that the HVAC system uses the appropriate technologies to minimise the radioactivity of gaseous radioactive waste discharges, including HEPA filters and iodine adsorbers. However, the specific technology for HEPA filters and how it is managed needs clarifying by resolving RO-UKHPR1000-0036 and is, therefore, subject to the following potential GDA Issue:

Potential GDA Issue 3 – GNSL has provided environmental justification for the choice of high efficiency particulate air filter design. However, further justification must be provided to demonstrate how best available techniques is applied.

Argument 2d: Minimise the radioactivity of gaseous radioactive waste discharges by installing and optimising the gaseous waste treatment system (TEG [GWTS])

GNSL argues that the GWTS manages gaseous radionuclides that are unavoidably generated during the operation of the UK HPR1000. The radionuclides present in the primary gaseous radioactive waste are mainly noble gases, iodine isotopes, carbon-14, tritium and other minor radionuclides (such as cobalt and caesium). The treatment techniques in the GWTS are selected for treating gaseous and particulate radionuclides present in the gaseous effluent. GNSL submitted an optioneering report to support the demonstration of BAT for the selected treatment techniques in the GWTS. We queried the optioneering process (RQ-UKHPR1000-0537) and the response to the RQ prompted an update to the optioneering report which improved the demonstration of BAT.

GNSL argues that the activated charcoal delay beds technique for processing noble gases is deemed to be the optimal option for UK HPR1000. This demonstrates BAT as it is a passive system requiring less maintenance and is used in other facilities in the UK. The regulators queried the management of the delay beds and the discharge of secondary waste (RQ-UKHPR1000-0429) and the management of the charcoal waste from the GWTS delay beds and HVAC iodine adsorbers (RQ-UKHPR1000-0430). The RQ’s responses confirmed that the charcoal in the GWTS delay beds is designed to last for the lifetime of the facility and is expected to be very low level waste (VLLW) and the HVAC iodine adsorbers waste is anticipated to be low level waste (LLW). The RQ’s responses also provided evidence how the future operator can optimise performance of the delay beds by managing parameters, including choice of charcoal media, temperature, pressure, humidity and flowrate. Filters are installed upstream and downstream of the delay beds to retain potential particles generated from the charcoal and, therefore, minimise the discharge of secondary waste.

GNSL argues that sampling and monitoring is carried out to ensure that the GWTS is operating as expected. Our assessment on the demonstration of BAT for the in-process sampling and monitoring is in a separate report (AR06).

We agree with GNSL that using delay bed technology in the UK HPR1000 design and the size of the delay beds is appropriate and demonstrates BAT.

Argument 2e: Minimise the radioactivity of aqueous discharges by optimising the liquid radioactive waste management system

GNSL argues that liquid radioactive waste will only be discharged to the environment after appropriate treatment, monitoring and sampling has demonstrated that concentrations of radioactive substances are appropriate for discharge. GNSL submitted an optioneering report to support the demonstration of BAT for the selected treatment techniques in the liquid radioactive waste management system (LRWMS). The regulators queried the optioneering process (RQ-UKHPR1000-0540) and the response to the RQ prompted an update to the optioneering report which improved the demonstration of BAT.

The techniques in the LRWMS include using filters, demineralisers and evaporators. The filters remove insoluble solid particles and fibres, the demineralisers remove soluble radioactive nuclides, and the evaporators extract distillate and keep radioactive substances in the concentrate. The demineralisers contain ion exchange resin and we queried the provision of expected decontamination factors (DFs) and how the DFs are optimised (RQ-UKHPR1000-0725). The response to the RQ confirmed that the expected DFs are determined from OPEX and demonstrated that the abatement efficiency is optimised by considering factors, including resin volume, equipment design parameters and other measures to maximise the efficiency (such as monitoring and sampling, and pH and impurity control). A future operator will need to demonstrate that the selection of resin and resin change strategy used in demineralisers is optimised and can be demonstrated to be BAT. We have raised Assessment Finding 5.

Assessment Finding 5: A future operator shall demonstrate that the UK HPR1000 will be operated in a way that represents best available techniques for the selection and change strategy of demineraliser resins for liquid waste management systems.

GNSL argues that in-process monitoring and discharge sampling and monitoring enables the future operator to appropriately manage the process to minimise waste in the LRWMS. Our assessment on the in-process and discharge sampling and monitoring is in a separate report (AR06).

The UK HPR1000 design benefits from inherent features that allow liquid to be reused. This is helped by applying appropriate techniques to concentrate and contain waste, where practicable. Overall, at this time, our preliminary conclusion is that the design of the UK HPR1000 liquid radioactive waste management system demonstrates BAT in GDA.

Argument 2f: Minimise the discharge of tritium

GNSL recognises that the primary sources of gaseous tritium are evaporation from the spent fuel pool (SFP) and the reactor pool (during refuelling). The regulators queried the design of the SFP and HVAC system in terms of minimising tritium production as optimisation of the SFP temperature and HVAC flow rate are important factors in minimising the discharge of tritium (RQ-UKHPR1000-0427). The response to the RQ resulted in an update to the 'Demonstration of BAT' and additional detailed analysis in the ‘Minimisation of the Discharge and Environment Impact of Tritium’. We agree with the conclusions from the analysis that there were low environmental benefits from optimising the factors affecting the evaporation from SFP and the reactor pool, and it would be disproportionate to change the design.

GNSL argues that following an assessment of techniques for the abatement of tritium, including the review of the International Atomic Energy Agency’s (IAEA) and the Organisation for Economic Co-operation and Development’s (OECD) technical reports, there are no available technologies for tritium abatement at low concentrations, and we support this view. Minimising tritium production at source is detailed in Argument 1d.

Argument 2g: Minimise the discharge of carbon-14

GNSL argues that following a technology assessment including the review of IAEA’s and OECD’s technical reports there are no commercially viable abatement techniques for gaseous carbon-14 that have been successfully used on a PWR. We agree with GNSL's view, however, given that carbon-14 is the main contributor to dose, we will expect a future operator to review the practicability of techniques for abating carbon-14 at the site-specific permitting stage and periodically thereafter. We have raised Assessment Finding 8.

Assessment Finding 8: A future operator shall review the practicability of techniques for abating carbon-14.

Claim 3: Minimise the impact of discharges on people and non-human biota

This claim is supported by 4 arguments (3a-3d) and extensive evidence. We summarise each argument below and provide our preliminary conclusions at this time.

Argument 3a: Partitioning of radionuclides has been optimised to minimise the impact on members of the public and the environment

GNSL argues that the design optimises the phase of tritium to the liquid phase to minimise the impact on members of the public and the environment. We agree that the measures taken in the design will enable the majority of tritium is to be discharged in the liquid phase. GNSL also argues that the design will not dictate the form for carbon-14 as the dose per unit release (DPUR) values for the liquid and gaseous phase are higher and lower for different DPUR cases.

We agree that the chemical form of tritium is controlled by the design as tritiated water (HTO) and discharging tritium in the liquid phase is preferable to discharging tritium in the gaseous phase. This is because the total DPUR for the annual tritium discharge into the receiving water environment is lower than that for the annual tritium discharge into the atmosphere. The DPUR for carbon-14 is lower to individuals but higher to the UK and the world population if discharged in gaseous phase and vice versa. Therefore, GNSL's approach to allow a future operator to define the balance between gaseous and liquid phase of annual discharges and solid waste of carbon-14 is acceptable and we have raised Assessment Finding 9.

Assessment Finding 9: A future operator shall optimise the balance between gaseous, liquid and solid phase of carbon-14.

The radiological assessment models used during GDA for the assessment of dose do not distinguish the chemical forms of carbon-14. Therefore, the contribution of the chemical forms of carbon-14 present in annual discharge has not been quantified, so we have raised Assessment Finding 10:

Assessment Finding 10: A future operator shall assess the chemical form of carbon-14 discharged to the environment and use this to inform future dose assessments.

Our assessment of dose to members of the public and the environment is provided in the generic site description and assessment of dose to the public and to wildlife assessment report (AR07).

Argument 3b: Eliminate solids, gases and non-aqueous liquids entrained within aqueous radioactive waste

GNSL argues that the techniques implemented in the LRWMS for eliminating solids, gases and non-aqueous liquids will minimise entrained radioactive waste before being discharged into the environment. GNSL recognises that a future operator will need to develop a management strategy during commissioning to ensure any non-aqueous liquid waste is separated from aqueous wastes before discharge and to develop management controls during the site-specific stage to further minimise the potential to contaminate aqueous waste with non-aqueous liquids.

Argument 3c: Optimisation of the discharge stack height

GNSL argues that the height of gaseous discharges from the main stack will help to minimise the dose to members of the public and the environment. GNSL has carried out a dose assessment based on an assumed stack height of 70 metres. This indicated that the total dose is below the dose constraint (300 micro Sievert per year [μSv/y]) and screening value (10 micro Gray per hour [μGy/h]) which is adequate for the GDA stage of assessment.

GNSL recognises that determination of the specific stack height will be a site-specific activity for the future operators and captured this as a forward action plan. An Assessment Finding has been raised in the monitoring assessment report (AR06).

Argument 3d: Optimisation of the location and timing of liquid discharge

The design of the UK HPR1000's liquid effluent management system allows the timing and location of effluent discharges to be controlled. GNSL has carried out a dose assessment based on the generic site, which indicated that the total dose is below the dose constraint (300μSv/y) and screening value (10μGy/h) which is adequate for the GDA stage of assessment.

The timing and location of effluent discharges should be progressed with a future operator at the site-specific design stage. We also note that design features enabling controlled discharges and suitable characterisation of liquid effluents are consistent with applying BAT (AR03).

Claim 4: Minimise the mass/volume of solid and non-aqueous liquid radioactive wastes and spent fuel

This claim is supported by 3 arguments (4a-4c) and extensive evidence. We summarise each argument below and provide our preliminary conclusions at this time. Further assessment of the disposal routes for wastes can be found in the solid waste, spent fuel and disposability assessment report (AR05).

Argument 4a: Minimise the volume of structures, systems and components that will become radioactive waste

The management, treatment and disposal considerations taken into account during the design of the UK HPR1000 minimise the volume of solid radioactive waste that is generated. A number of SSCs have been removed, while maintaining the systems' safety and operational functions, including 39 manual valves, along with relevant piping systems for the reactor coolant system. This will reduce the volume of solid radioactive waste produced during plant maintenance and decommissioning. Items of plant equipment have also been removed by developing the design, including a non-regenerative heat exchanger which will reduce radioactive waste.

GNSL states that the UK HPR1000 contamination and access control approach is based on the international relevant good practice (RGP). The approach includes separating active and non-active work in controlled and supervised areas to limit the spread of contamination and, therefore, reduce the secondary waste.

The buildings in the nuclear island that are in GDA scope are within close proximity of each other, which is beneficial for the abatement of radioactive waste. Buildings outside the nuclear island and not subject to detailed design in GDA include the conceptual radioactive waste stores. These will benefit from being close to the nuclear island to ensure waste packages are not transferred long distances and pipe length is minimised to prevent leakage. A future operator will need to demonstrate that the radioactive waste buildings are suitably located close to the nuclear island.

Our preliminary conclusion is that the evolution of the design has removed some SSCs that would otherwise become radioactive waste. The zoning approach is based on international RGP and buildings in the nuclear island are close to each other.

Argument 4b: Minimise the volume of solid radioactive waste by extending the design life of SSC and reusing maintenance equipment and tools

The UK HPR1000 has been designed with a minimum design life of 60 years. Replacing structures, systems and components (SSCs) with a limited operational life is unavoidable and GNSL has considered reducing them less often to minimise the volume of solid radioactive waste.

The size and operating conditions of the filters and demineralisers have been optimised so they do not need replacing as often and to reduce the amount of solid radioactive waste created. The regulators queried the configuration and management of demineralisers to optimise the treatment and flexibly balance liquid discharges versus production of solid waste (RQ-UKHPR1000-0783). The response to this RQ provided evidence of the flexible configuration of the demineralisers, which gives any future operator a choice in how they choose to operate them. For example, the design of the demineraliser unit of the liquid waste treatment system (LWTS) allows the future operator to use the three resins beds in series, as two in series or only one on its own to optimise the abatement and liquid discharges versus the production of solid waste. A future operator will need to demonstrate that the selection of resin and resin change strategy used in demineralisers is optimised and can be demonstrated to be BAT. We have raised Assessment Finding 5.

Assessment Finding 5: A future operator shall demonstrate that the UK HPR1000 will be operated in a way that represents best available techniques for the selection and change strategy of demineraliser resins for liquid waste management systems.

The regulators queried the use of the first delay bed as a guard bed (one used to protect the main delay bed in the event of problems, for example higher moisture levels) and how the delay beds parameters (humidity and pressure) will be optimised to minimise discharges and extend the life of the delay beds (RQ-UKHPR1000-0429). The RQ response confirmed that the first delay bed is not a sacrificial guard bed and can be bypassed without impacting the ability of the delay bed system. The flexible system allows the bypassed delay bed to be maintained and returned to service. GNSL also confirmed that the temperature, humidity, pressure and flowrate are monitored to optimise the operation of the delay beds, and the waste from the delay beds is expected to be LLW during decommissioning (RQ-UKHPR1000-0430).

The measures detailed by GNSL help to reduce the volume of solid radioactive waste that will be produced and collectively demonstrate BAT. Resolving the HEPA filter choice RO (RO-UKHPR1000-0036), see Argument 2c also demonstrates BAT.

Argument 4c: Reducing the volume of solid waste and non-aqueous liquid waste requiring disposal by adopting efficient segregation, treatment techniques and container selection

GNSL recognises that the solid and non-aqueous liquid radioactive wastes generated by the UK HPR1000 will place demands on the capacity of current and planned disposal routes in the UK. GNSL argues that the design includes a number of techniques and facilities that will allow a future operator to reduce the volume of solid and non-aqueous liquid radioactive wastes requiring disposal.

GNSL carried out optioneering studies to determine the preferred options of solid radioactive waste processing techniques and packaging, considering the principles of BAT. The selected techniques demonstrate that the volume of solid and non-aqueous liquid radioactive wastes will be minimised.

GNSL observes that decay storage is a recognised practice in the nuclear industry and is particularly useful for managing boundary waste (that is, ILW that decays to LLW). GNSL argues that the UK HPR1000 has sufficient storage capacity for decay storage. The regulators queried the design and management of the ILW interim storage facility (BQZ) (RO-UKHPR1000-0040). The GNSL response states that the construction of the store using a 2-phased approach can provide knowledge from the construction and operation of the first phase to incorporate learning from experience and potential continuous improvement for the second construction phase. The RO remains open at this time and we will monitor the additional justification of the design in demonstrating BAT.

We recognise that decay storage can reduce the activity of waste that need disposing of, and that this is a particularly useful approach for radionuclides with short-half lives. We also support plans for early waste treatment and conditioning, where appropriate, as de-watering and immobilisation help to ensure containment and reduce future burdens where it is shown that robust and disposable products can be produced, as long as options are not ruled out for a future operator.

Claim 5: Select the optimal disposal routes for wastes

This claim is supported by 3 arguments (5a-5c) and extensive evidence. We summarise each argument below and provide our preliminary conclusions at this time. Further assessment of the disposal routes for wastes can be found in the solid waste, spent fuel and disposability assessment report (AR05).

Argument 5a: Providing waste management facilities with sufficient space and services to allow a future operator to install a range of waste management processes

The design of the UK HPR1000 waste treatment facilities includes the space and services that are required to install the equipment necessary to characterise, treat and store waste. This, it is argued, will allow a future operator to implement the optimal waste disposal route for radioactive solid waste. Therefore, for GDA, GNSL has aimed to demonstrate that waste could be disposed of to appropriate routes based on currently established practice and national plans. Future site operators would need to select the actual disposal routes and demonstrate that they are BAT.

Characterisation, sorting, treatment and storage provisions will allow consignment to appropriately permitted routes, including those currently provided by waste management service providers. The regulators queried the arrangements for monitoring and sampling before disposal and whether the waste packages meet the requirements for disposal (RQ-UKHPR1000-0633). The response to the RQ provided an example approach for a HLW/ILW boundary waste which included:

- gamma spectrometry at source and/or before packaging
- calculation of the expected decay time
- transfer to the relevant storage area
- monitoring/inspection during the storage period
- retrieval from the storage area once the package has decayed to the lower category
- monitoring to confirm it can be disposed of or transferred to another building

As the characterisation strategy for solid and non-aqueous liquid waste has only been developed at a concept level during GDA we have raised an Assessment Finding in our solid waste assessment report (Environment Agency, 2021e).

Overall, we recognise that the design does not constrain future operators and our preliminary conclusions are that GNSL has provided a sufficient case in this respect for GDA.

Argument 5b: All solid and non-aqueous liquid lower activity wastes have been demonstrated to be compatible with waste treatment and disposal services available in the UK by obtaining 'agreements-In-principle' from service providers

GNSL has engaged with the suppliers of waste management services for solid and non-aqueous radioactive waste in the UK. Agreement in principle has been obtained for lower activity wastes (LAW) arisings from the UK HPR1000 with LLWR Ltd. The regulators challenged GNSL to find out if there will be hazardous materials associated with the LLW wastes arising from the UK HPR1000 (RQ-UKHPR1000-0636). GNSL's response to the RQ included a number of non-hazardous pollutants. We are satisfied that GNSL has assessed the inventory for hazardous materials and non-hazardous pollutants, for this stage of GDA.

We consider this 'agreement in principle' to provide a suitable demonstration of waste compatibility with current disposal routes and is based on high level descriptions of waste inventory and characteristics. The future operator would be expected to confirm future compatibility by further detailed assessment against waste acceptance criteria at that time.

Argument 5c: Disposability assessments have been carried out to demonstrate that all solid HAW are compatible with disposability concepts prepared by Radioactive Waste Management Ltd for the UK's proposed GDF

GNSL has explored the requirements for the disposability assessments and is obtaining disposability advice from Radioactive Waste Management (RWM). The regulators queried the disposability assessment (RO-UKHPR1000-0041), including seeking assurance that the GNSL and RWM plans are aligned and can be completed within GDA timescales. The regulators queried the management of the in-core instrument assemblies (ICIAs) (RO-UKHPR1000-0037), including seeking a justification for the decay storage. We note that the 2 ROs remain open at this time and outcomes from the resolution plans' actions could influence BAT for generating, minimising and managing radioactive waste in the UK HPR1000.

The disposability of all solid HAW produced from the UK HPR1000 operation is yet to be demonstrated and confirmed with advice from RWM. This is discussed further in a separate assessment report (AR04).

Appendix 7 - Consultation response form

We welcome your views on our generic design assessment of General Nuclear System Ltd's UK HPR1000. Please use this form if you are responding by email or post rather than online.

Please complete the questions and where there is a free text field, give as much information as possible to support your answer.

How we will use your information

The Environment Agency will look to make all responses publicly available during and after the consultation, unless you have specifically requested that we keep your response confidential.

We will not publish names of individuals who respond.

We will also publish a summary of responses on our website in which we will publish the name of the organisation for those responses made on behalf of organisations.

In accordance with the Freedom of Information Act 2000, we may be required to publish your response to this consultation, but will not include any personal information. If you have requested your response to be kept confidential, we may still be required to provide a summary of it.

The Environment Agency is the data controller for the personal data you provide. For further information on how we deal with your personal data please see our Personal Information Charter on gov.uk (https://www.gov.uk/government/organisations/environment-agency/about/personal-information-charter) or contact our Data Protection team.

Address: Data Protection team, Environment Agency, Horizon House, Deanery Road, Bristol, BS1 5AH

Email: dataprotection@environment-agency.gov.uk

Returning your response

The consultation will run for 12 weeks from 11 January 2021.

The closing date for responses is 4 April 2021. Any responses we receive after this date will not be included in the analysis.

We would like you to use this form if you are not submitting your response online. You can return it by email to nuclear@environment-agency.gov.uk using the heading 'CONSULTATION: GDA of UKHPR1000'. Please use this email address if you have any questions regarding this consultation.

Or by post to:

Dr Paula Atkin
Environment Agency
Ghyll Mount
Gillan Way
Penrith 40 Business Park
Penrith
Cumbria CA11 9BP

Section 1: About you

There are 15 consultation questions that we would like you to answer. But first, to help us analyse the responses we receive we'd like to understand more about you or the organisation you represent.

Q1. Please tell us if you are responding as an individual or on behalf of an organisation or group.

Please select one answer only from the following options:

☐ Responding as an individual

☐ Responding on behalf of an organisation or group

☐ Other

If you're responding on behalf of an organisation or group, please tell us who you are responding on behalf of.

____

If you selected other, please specify.

Q2. Keeping up to date

We would like to keep you informed about the outcomes of the consultation.

If you would like to receive an email acknowledging your response and be notified that the summary of responses and final decision document has been published please give us your email address below.

Your email address:

____

By providing us with your email address you consent for us to email you about the consultation. We will keep your details until we have notified you of the responses document publication and decision document publication.

We will not share your details with any other third party without your explicit consent unless required to by law.

You can withdraw your consent to receive these emails at any time by contacting us at:

nuclear@environment-agency.gov.uk with the subject "CONSULTATION: GDA of UKHPR1000".

Q3. Can we publish your response? We will not publish any personal information or parts of your response that will reveal your identity.

☐ Yes

☐ No

Q4. Please tell us how you found out about this consultation?

☐ From the Environment Agency

☐ From another organisation

☐ Through an organisation/group/club you’re a member of

☐ Press article

☐ Social media e.g. Facebook, Twitter

☐ Through a meeting you attended

☐ Other (please specify)____

Section 2: Your views

This consultation seeks your views on our preliminary conclusions following our detailed assessment of General Nuclear System Limited's (GNSL) UK HPR1000 new nuclear power station design, and on the environmental aspects of the design. We will carefully consider your views in reaching our decision on whether to issue a statement of design acceptability.

1. Do you have any views or comments on our preliminary conclusions on management systems?

2. Do you have any views or comments on our preliminary conclusions on strategic considerations for radioactive waste management?

3. Do you have any views or comments on our preliminary conclusions on the process for identifying BAT or on the techniques used to minimise production and disposal of radioactive waste?

4. Do you have any views or comments on our preliminary conclusions on minimising the discharges and impact of gaseous and liquid waste, and our proposed limits and levels?

5. Do you have any views or comments on our preliminary conclusions on the management and disposal of solid radioactive waste and spent fuel?

6. Do you have any views or comments on our preliminary conclusions on monitoring discharges and disposals of radioactive waste?

7. Do you have any views or comments on our preliminary conclusions on the impact of discharges of radioactive waste?

8. Do you have any views or comments on our preliminary overall conclusion on radioactive substances permitting?

9. Do you have any views or comments on our preliminary conclusions on water abstraction?

10. Do you have any views or comments on our preliminary conclusions on discharges to surface waters and groundwater?

11. Do you have any views or comments on our preliminary conclusions on the operation of installations?

12. Do you have any views or comments on our preliminary conclusions on the control of major accident hazards?

13. Do you have any views or comments on our preliminary conclusions on the measures to prevent and minimise leakage of fluorinated greenhouse gases and ozone-depleting substances?

14. Do you have any views or comments on our preliminary overall conclusion on the acceptability of the design?

Additionally:

15. Do you have any overall views or comments to make on our assessment, not covered by the previous questions?

Would you like to find out more about us or your environment?

Then call us on

03708 506 506 (Monday to Friday, 8am to 6pm)

email

enquiries@environment-agency.gov.uk

or visit our website

www.gov.uk/environment-agency

incident hotline

0800 807060 (24 hours)

floodline

0345 988 1188 (24 hours)

Find out about call charges (www.gov.uk/call-charges)

Environment first:

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