Environment Agency

Generic design assessment

UK EPR^{TM} nuclear power plant design by AREVA NP SAS and Electricité de France SA

Decision document

We are the Environment Agency. We protect and improve the environment and make it **a better place** for people and wildlife.

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We cannot do this alone. We work closely with a wide range of partners including government, business, local authorities, other agencies, civil society groups and the communities we serve.

Published by:

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Bristol BS1 5AH
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Further copies of this report are available from our publications catalogue: http://publications.environment-agency.gov.uk or our National Customer Contact Centre: T: 03708 506506

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Foreword

I'm pleased to introduce our decision document on EDF and AREVA's UK EPR™ reactor design and the views that we have formed of it during our Generic Design Assessment (GDA) programme. We have also published the equivalent document on the AP1000® design, the other reactor design in the GDA programme which was submitted by Westinghouse.

We have decided to issue an *interim* statement of design acceptability for the UK EPR because we consider that there are two key "GDA Issues" (or caveats) that apply to the design's acceptability. The two issues relate to learning from Fukushima, and ensuring that design changes arising from safety related GDA Issues are assessed for any environmental implications. Both GDA issues must be resolved before we would issue a full Statement of Design Acceptability, and before construction begins on the nuclear island of a new nuclear power station based on the UK EPR.

We and the Office for Nuclear Regulation (ONR, formerly HSE's Nuclear Directorate) are independent Regulators conducting robust assessments. When we jointly developed the GDA process and started our respective assessments about four years ago, our key objectives were:

- to have early influence on potential reactor designs that might be built in the UK so that we could be confident that they would meet the high standards that we require of safety, security, environment protection and waste management;
- to provide potential developers and investors in any new nuclear stations with our views about the designs, so reducing the associated regulatory risks;
- by assessing and influencing designs early, to help to ensure that any developments can achieve their project timescales and costs because they would be more fully specified before significant construction;
- to establish, subject to normal national and commercial security constraints, an open and transparent process of assessment; and
- to build a professional and synergistic working relationship between the nuclear Regulators as we worked jointly to develop, implement and carry out our GDA process.

The GDA programme has been successful and we have met these objectives. In March 2008 we and HSE jointly published our preliminary assessment of the reactor designs. We also established our joint public involvement process so that questions about the designs could be posed to, and answered by, the reactor designers. We see both questions and answers and have used these to help inform our assessments. On 28 June 2010, our consultation began on our preliminary conclusions following our detailed assessment of the UK EPR reactor design. The consultation closed on 18 October 2010 and we thank all who took the time and trouble to send us their views. We have carefully considered all of the comments received and have used them to inform our decision. Our responses to the issues raised are set out in this document. This document is also published in parallel with ONR's "GDA Step 4" reports on the AP1000 and UK EPR designs.

At a late stage in our assessment the accident at Fukushima occurred. As a consequence we did not believe that it was appropriate to draw conclusions from our GDA assessment work in June 2011 as originally planned, nor publish our GDA Decision Documents, until the lessons learnt from Fukushima emerged. We decided to extend our assessments to allow us to take account of HM Chief Inspector of Nuclear Installations' report on the implications of Fukushima. We also introduced an additional GDA Issue to take account of the Fukushima lessons learnt work. The Chief Inspector's report has now been issued and EDF and AREVA have provided a resolution plan describing how they are addressing its recommendations. While we will continue to assess their progress on this matter, we feel it is now appropriate to publish our decision on the acceptability of the UK EPR design.

There are some areas where work would be required by the *operators* if they decide to pursue construction of a UK EPR. These relate to providing further information and resolving technical issues for a site-specific design. We identify these matters as "*Assessment Findings*" in our reports. We are confident that these matters are resolvable and that they can be addressed by the operator as part of any future site-specific application.

David Jordan

Director of Operations, Environment Agency, December 2011

Executive summary

Introduction to GDA

1 As the leading organisation working to protect the environment, it is the Environment Agency's role to regulate discharges and waste disposals from nuclear power stations in England and Wales and to ensure their impact on air, water and land is acceptable and minimised.

2 In response to growing interest in nuclear power and potential applications to build new nuclear power stations in England and Wales, we developed a new approach, Generic Design Assessment (GDA), for assessing the environmental impacts of new reactor designs. GDA means that we assess the acceptability of the generic environmental aspects and the nuclear reactor design before individual site applications are made. This approach allows us to get involved at the earliest stage where we can have most influence and where lessons can be learned for site-specific applications. It also gives us additional time to address regulatory and technical issues with designers and potential operators.

3 The new GDA approach has given us the opportunity to work more closely with the Office for Nuclear Regulation[1] (ONR), providing effectively a 'one-stop-shop' for nuclear regulation. The process has allowed a rigorous and structured examination of detailed environmental, safety and security aspects of the reactor designs, over approximately four years. We believe that GDA has improved efficiency both for the Regulators and the nuclear industry, and is delivering greater protection for both people and the environment. GDA cannot provide a complete assessment of a final "site-specific" design as there will be other issues, operator specific or site related, that we would expect to be considered during the environmental permitting and site licensing stages.

4 When we issued our guidance on GDA in 2007, we envisaged that when we came to a decision on the acceptability of a reactor design, we may need to attach caveats. Previous experience in similar projects has also shown that it is not unusual for industry to take significant time to completely resolve some of the technical issues raised by Regulators, in view of the need for new analysis, tests or research, etc., to be carried out or for the design details to be completed. Also, there will be some requirements for commissioning tests, maintenance schedule, and operating rules, etc., that can only be fully addressed by a future operator. In these instances, a 'satisfactory' response to a technical issue for the GDA could be one where the matter is not fully resolved or confirmed, but Regulators judge it is acceptable for it to be carried forward for future resolution. In the course of GDA we have clarified that if any of the issues are considered by Regulators to be particularly significant but still resolvable, then these would be identified as GDA Issues. In these cases the statement of design acceptability would be labelled as 'Interim', and we expect the Requesting Parties to produce a resolution plan that identifies how the Issue would be addressed and closed out.

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[1] The Office for Nuclear Regulation (ONR) was created on 1st April 2011 as an Agency of the Health and Safety Executive (HSE). It was formed from HSE's Nuclear Directorate and has the same role. In this report we therefore generally use the term "ONR", except where we refer back to documents or actions that originated when it was still HSE's Nuclear Directorate.

5 Electricité de France SA and AREVA NP SAS ('EDF and AREVA') submitted their UK EPR™ nuclear power plant design for GDA in August 2007. EDF and AREVA published their submission on their website (http://www.epr-reactor.co.uk) and invited people to comment. The submission has been revised during GDA as would be expected to reflect developments. The current version on the website is up to date and is the basis of our detailed assessment and decision.

6 GDA was in two stages: the preliminary assessment and detailed assessment. We completed the preliminary assessment and published our findings in March 2008. On 28 June 2010, our consultation began on our preliminary conclusions following our detailed assessment of the UK EPR reactor design. This consultation closed on 18 October 2010. We have carefully considered all of the comments received and used them to help inform our decision. Our responses to the issues raised are set out in this decision document.

7 We conducted our GDA work in an open and transparent way and communicated with industry, academics, trade unions, non-Governmental Organisations and other interested groups and individuals during the process.

8 Generation of radioactive waste is intrinsically linked to the detailed design of a reactor, together with its associated plant. We require generation of radioactive waste to be minimised, and so GDA has focussed on radioactive waste design issues. Permitting the disposal and discharge of radioactive wastes has also traditionally been the area of regulation that has had the longest lead time for our permitting of new nuclear power stations. Additionally, we have also looked at key aspects of the design relating to other areas such as abstraction and discharges to water, pollution control issues, and management of non-radioactive waste.

9 This decision document summarises our detailed assessment findings on environmental aspects of the UK EPR nuclear power plant design. We have used the comments and issues raised in our consultation to help inform our decisions. We are content with the environmental aspects of the design, that it should meet the high standards we expect, so will issue an Environment Agency interim statement of design acceptability (interim SoDA, or iSoDA).

10 At a late stage in our assessment the accident at Fukushima occurred. The key impact on GDA was that we did not believe that it was appropriate to draw conclusions from our GDA assessment work in June 2011 as originally planned, nor conclude our GDA Decisions, until the lessons learnt from Fukushima emerged. We extended our assessment to allow us to take account of HM Chief Inspector of Nuclear Installations' report on the implications of Fukushima. We also introduced an additional GDA Issue to take account of the Fukushima lessons learnt work. The Chief Inspector's report has now been issued and EDF and AREVA have provided a resolution plan describing how they are addressing the recommendations. While we will continue to assess their progress on this matter, we feel it is now appropriate to publish our decision on the acceptability of the UK EPR design.

11 We have also identified in our decision document some assessment findings that we would expect to be addressed during site permitting and licensing, reactor procurement, design development, construction, or commissioning.

12 When all GDA Issues have been addressed to our satisfaction then the interim status of the SoDA will be reviewed and, if appropriate, a final SoDA will be provided, together with a report describing the basis of the GDA Issue resolution. Only when all GDA Issues related to the iSoDA have been addressed to our satisfaction will we confirm to ONR that we are content that it considers providing Consent to start nuclear safety related construction of the 'nuclear island' of the power station.

13 Should a SoDA be issued, the design and safety case will continue to evolve as the detailed design progresses and site-specific applications are developed. We would expect that the generic reactor design submitted for GDA and the SoDA will be used to underpin the permissions to construct a fleet of reactors identical except for site-specific requirements and the requirements of different operators.

Our decision, following consultation

14 We have now carried out a detailed assessment of EDF and AREVA's submission for the UK EPR nuclear power plant design and our conclusion, following consultation, is that we could issue an interim Statement of Design Acceptability (iSoDA) for the UK EPR. The iSoDA is reproduced at Annex 1 of this document. We have considered all the responses to our consultation and ONR's assessment before coming to a final decision on the acceptability of the UK EPR. Our decision is subject to two GDA Issues, both joint with ONR. EDF and AREVA have proposed Resolution Plans to address both GDA Issues. With ONR, we have reviewed these plans, and consider them credible.

GDA Issues

15 The two GDA Issues are:

a) Provide a consolidated Final GDA Submission, including agreed design change for the UK EPR. The Issue reflects that EDF and AREVA will need to continue to control changes to the GDA submission documents, resulting from the management of possible changes to the design, until the issue of final SoDA. Design changes are also possible from resolution of the GDA Issues identified by ONR.

b) Consider and action plans to address the lessons learned from the Fukushima Event

Assessment findings

16 In reaching our decision we identified 18 assessment findings. We expect future operators to address the findings during the detailed design, procurement, construction or commissioning phase of any new build project.

Reference	Assessment finding
UK EPR-AF01	The future operator shall, at the detailed design stage, identify any changes to the 'reference case' for solid radioactive waste and spent fuel strategy, and provide evidence that the site-specific integrated waste strategy (IWS) achieves the same objectives.
UK EPR-AF02	The future operator shall, at the detailed design stage, provide an updated decommissioning strategy and decommissioning plan.
UK EPR-AF03	Future operators shall keep the removal of secondary neutron sources (to further minimise creation of tritium) under review. EDF and AREVA should provide future operators with relevant EPR operational information when available to facilitate their reviews of Best Available Techniques (BAT)

Reference	Assessment finding
UK EPR-AF04	Future operators shall, during the detailed design phase for each new build project, review BAT on minimising the production of activated corrosion products for the following matters, where possible improvements were identified in the PCER: i) corrosion resistance of steam generator tubes; ii) electro-polishing of steam generator channel heads; iii) specification of lower cobalt content reactor system construction materials; iv) further reducing use of stellites in reactor components, in particular the coolant pump. Where appropriate, any improvements considered BAT should be incorporated into the new build.
UK EPR-AF05	Future operators shall, before the commissioning phase, provide their proposals for how they intend to implement zinc injection. The proposals shall be supported by an assessment of the impact of zinc injection on waste and crud composition.
UK EPR-AF06	Prior to construction of the conventional and nuclear island liquid effluent discharge tank systems, future operators shall demonstrate that site-specific aspects such as size and leak-tight construction techniques are BAT.
UK EPR-AF07	Future operators shall, before the commissioning phase, provide an assessment to demonstrate that proposed operational controls on the fuel pool are BAT to minimise the discharge of tritium to air.
UK EPR-AF08	Future operators shall, during the detailed design phase, provide their proposals for the operational management of the Liquid Waste Processing System to minimise the discharge of radioactivity from the site so that exposures of any member of the public and the population as a whole are kept as low as reasonably achievable (ALARA) and to protect the environment. The proposals should be supported by a BAT assessment to show that the use of the evaporator, the choice of filter porosity and the demineralisation media have been optimised to minimise the dose to members of the public. The future operator shall also provide evidence that the Water Treatment Systems have sufficient capacity and resilience to cope with all the aqueous radioactive waste arisings consigned to the evaporator by the proposals. The proposals should consider all plant states, including for example outages and unavailability due to maintenance or breakdown.
UK EPR-AF09	Future operators shall, during the detailed design stage, provide a predicted mass balance showing how their proposed aqueous radioactive waste management regime will affect the disposal of carbon-14 to the gaseous, solid or aqueous routes. For each route the form of carbon-14 expected shall be provided. For solid wastes the quantities of each type of waste shall be provided with expected carbon-14 content.

Reference	Assessment finding
UK EPR-AF10	The future operator shall provide confidence that adequate radioactive waste management cases (RWMCs), supported by appropriate stage Letters of Compliance (LoCs), can be developed for all intermediate level waste (ILW) on the timescales identified in EDF and AREVA’s plan for disposability of ILW
UK EPR-AF11	The future operator shall provide evidence during the detailed design phase that the proposed specific techniques for preventing and, where that is not possible, minimising the creation of low level waste (LLW) and ILW are BAT.
UK EPR-AF12	The future operator shall provide evidence during the detailed design phase that the proposed specific techniques for treating and conditioning of LLW and ILW before disposal are BAT.
UK EPR-AF13	If smelting of any LLW is pursued, the future operator shall demonstrate that the conditions of acceptance of the selected smelting facility can be met.
UK EPR-AF14	If incineration of any LLW is pursued, the future operator shall demonstrate that the conditions of acceptance of the selected incineration facility can be met.
UK EPR-AF15	If incineration of any ILW is pursued, the future operator shall demonstrate that the conditions of acceptance of the selected incineration facility can be met.
UK EPR-AF16	The future operator shall, before the commissioning phase, propose techniques for the interim storage of spent fuel following a period of initial cooling in the pool. The future operator shall provide an assessment to show that the techniques proposed are BAT.
UK EPR-AF17	The future operator shall, before the commissioning phase, provide confidence that adequate RWMCs, supported by appropriate stage LoCs and taking due account of necessary storage periods, can be developed for spent fuel on the timescales identified in EDF and AREVA's plan for disposability of spent fuel.
UK EPR-AF18	Future operators shall provide: a) during the detailed design phase, the location and arrangement of sampling and continuous monitoring facilities for gaseous and aqueous wastes supported by an assessment that these will provide representative sampling and monitoring; b) during the detailed design phase and before final equipment selection, the details of equipment and techniques to be used for analysis of gaseous, aqueous and solid wastes supported by an assessment that these represent BAT for monitoring.

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1 About this decision document

17 The purpose of this document is to explain the Environment Agency's decision, following assessment and consultation, regarding the acceptability of a new nuclear power plant design, the UK EPR^{TM}, by Electricité de France SA and AREVA NP SAS (EDF and AREVA) (the 'requesting party').

18 The Office for Nuclear Regulation[2] (ONR) is also assessing the UK EPR from a safety and security viewpoint. Although we work closely with ONR, this decision document is only about the Environment Agency's assessment and not ONR's.

19 This document provides:

a) An introduction to our role in nuclear regulation and the basis for GDA (Chapter 2).

b) An outline of the UK EPR design (Chapter 3).

c) A guide to our detailed assessment (Chapter 4).

d) Our GDA conclusions, followed by our detailed assessment (Chapters 5 to 14).

e) Our final decision (Chapter 15).

f) Annexes supporting the decision document (Annexes 1 to 8).

20 The detailed assessments provided in Chapters 5 – 14 are essentially the same as those provided in the consultation document but updated, where appropriate, to reflect:

a) Our assessment of any further information provided by EDF and AREVA since the consultation date.

b) Any further work that we said, in the consultation document, that we intended to do.

c) Any matters arising from ONR's GDA Step 4 work that are relevant to our assessment.

d) Our consideration of any consultation responses relevant to the topic.

21 The consultation questions are listed in Annex 5 and the responses we received are considered in relevant sections throughout our decision document. A number of responses did not directly concern GDA but are summarised in Annex 8 with our response.

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[2] The Office for Nuclear Regulation (ONR) was created on 1st April 2011 as an Agency of the Health and Safety Executive (HSE). It was formed from HSE's Nuclear Directorate and has the same role. In this report we therefore generally use the term "ONR", except where we refer back to documents or actions that originated when it was still HSE's Nuclear Directorate.

2 Introduction

2.1 The Environment Agency

22 Our corporate strategy **Creating a better place 2010-2015** (Environment Agency, 2009b) sets out our aims and describes the role we will play in being part of the solution to the environmental challenges society faces.

23 Our strategy aims to create a better place by securing positive outcomes for people and wildlife, in five key areas. We will:

a) act to reduce climate change and its consequences;

b) protect and improve water, land and air;

c) work with people and communities to create better places;

d) work with businesses and other organisations to use resources wisely;

e) be the best we can.

2.2 Our role in nuclear regulation

24 We regulate the environmental impacts of nuclear sites (such as nuclear power stations, nuclear fuel production plants, plants for reprocessing spent nuclear fuel) through a range of environmental permits. These permits may be needed for one or more of the site preparation, construction, operation and decommissioning phases of the plant's lifecycle.

25 The permits we issue can include conditions and limits. In setting these, we take into account all relevant national and international standards and legal 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:

http://www.defra.gov.uk/environment/policy/permits/index.htm

http://www.environment-agency.gov.uk/business/topics/permitting/32320.aspx

http://www.decc.gov.uk/en/content/cms/meeting_energy/nuclear/radioactivity/decc/legislation/epr2010/epr2010.aspx

http://www.environment-agency.gov.uk/business/sectors/32533.aspx

26 We inspect sites to check that the operator is complying with the conditions and limits and that they have arrangements in place to help ensure compliance. We may take enforcement action (for example, issuing an enforcement notice or taking a prosecution) if they are not.

27 We regularly review permits, and vary them if necessary, to ensure that the conditions and limits are still effective and appropriate.

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

2.3 Our regulatory role in the development of new nuclear power stations

29 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 plants 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 two phases.

30 In the first phase, generic design assessment (GDA), we carry out detailed assessments of candidate designs and, at the end, provide a statement about the acceptability of the design. We may attach GDA Issues (i.e. caveats) to the statement. We have completed this phase now – this decision document is about our assessment of the UK EPR design.

31 In the second phase, we would receive applications for environmental permits for specific sites. In determining these applications, we will take full account of the work we have done during GDA, so that our efforts will be focused on operator and site-specific matters including how the operator has addressed any caveats attached to the statement of acceptability.

32 For GDA, we have worked closely with ONR to assess areas where we have overlapping regulatory responsibility including radioactive waste and spent fuel management, and management arrangements for control of design changes, and control of GDA submission documents.

2.4 Our input to the Government's facilitative actions on nuclear new build

33 We have provided specialist advice, where appropriate, and responded to consultations relating to the actions taken by Government to:

a) reduce the regulatory and planning risks associated with investing in new nuclear power stations;

b) ensure that operators of new nuclear power stations set aside funds to cover the costs of decommissioning and long-term waste management and disposal.

34 These include:

a) **Strategic siting assessment and Nuclear National Policy Statement (NNPS) development** – the NNPS identifies the sites that, at the strategic level, are potentially suitable for the deployment of new nuclear power stations by the end of 2025 together with relevant government policy for energy infrastructure. The NNPS is part of a suite of Energy National Policy Statements, that were designated by Government following consultation and voting in Parliament in 2011 (DECC, 2011a). The National Policy Statements provide the framework for decisions on planning consent (Development Control Orders) by the Infrastructure Planning Commission or, if implemented, the Major Infrastructure Planning Unit of the Planning Inspectorate.

b) **Justification** – Government's approach is that 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 health detriment. On 18 October 2010 the Secretary of State for Energy and Climate Change, Chris Huhne, published his decisions as Justifying Authority that two nuclear reactor designs, EDF and AREVA's UK EPR and Westinghouse's AP1000, should be Justified. The decisions have been given effect by statutory instruments. These were approved by the House of Lords on 17 November and by the House of Commons on 24 November. Copies of the statutory instruments are available on the Legislation.gov.uk: The Justification Decision (Generation of Electricity by the AP1000 Nuclear Reactor) Regulations 2010 and The Justification Decision (Generation of Electricity by the EPR Nuclear Reactor) Regulations 2010

c) **Funded decommissioning programme** – The Energy Act 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. In December 2011, the Government issued statutory guidance for new nuclear operators to produce plans for funding the decommissioning of their power stations and managing their radioactive waste. This will enable new nuclear operators to come forward with clear plans to deal with decommissioning and radioactive waste management for approval by the Secretary of State. (DECC, 2011b).

2.5 About Generic Design Assessment (GDA)

35 GDA means that we can begin assessing the acceptability of the environmental aspects of an overall 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.

36 Our guidance (Environment Agency, 2007) sets out in detail the process that we follow during GDA. It has six main elements:

a) **Initiation** – we make an agreement with the requesting party under section 37 of Environment Act 1995 and receive a submission.

b) **Preliminary assessment** – we make an outline examination of the submission to find out if:

   i) we need further information;

   ii) there are any issues that are obviously unacceptable;

   iii) any significant design modifications are likely to be needed.

c) **Detailed assessment** – we examine the submission in detail to decide initially if we might issue a statement of design acceptability.

d) **Consultation** – we consult widely on our initial view. We produce a consultation document explaining our view and, if we consider that we might issue a statement of design acceptability, we may set out a draft statement appropriate to the design.

e) **Post consultation review** – we carefully consider all relevant responses to the consultation.

f) **Decision and statement** – we decide whether we should issue a statement of design acceptability and, if so, what GDA Issues, if any, we should attach to it. We publish a document that provides the background to and basis for our findings.

37 The remainder of this chapter describes how we have applied this process, so far, to the UK EPR in GDA.

2.5.1 Initiation and preliminary assessment

38 Our process for the first stage of GDA for the UK EPR is described in our report on our preliminary assessment (Environment Agency, 2008a). In summary:

a) We set up an agreement with EDF and AREVA to carry out GDA of the UK EPR, which came into effect in July 2007.

b) The Joint Programme Office (JPO) received EDF and AREVA's submission in August 2007.

c) With HSE, we launched the 'public involvement process' in September 2007. This enabled the public to view and comment on the reactor designs undergoing GDA. (See:http://www.hse.gov.uk/newreactors/publicinvolvement.htm)

d) We carried out our preliminary assessment and concluded that we needed further information.

e) We raised a Regulatory Issue on EDF and AREVA in February 2008 setting out the further information that we needed.

f) We published our report on our preliminary assessment in March 2008.

g) EDF and AREVA completely revised their submission during 2008 and provided a pre-construction environmental report (PCER) with supporting documents. They reviewed and updated the PCER in March 2010, and March 2011.

2.5.2 Detailed assessment

39 We began our detailed assessment in June 2008.

Our assessment process

40 We have carried out our assessment using the information EDF and AREVA provided in the documents listed in Schedule 1 of Annex 1 (the 'submission'). These contain the additional information provided in response to our Regulatory Issue and in response to 33 Technical Queries and four Regulatory Observations that we raised during our detailed assessment. EDF and AREVA also arranged a number of site visits to support the claims they were making.

41 Our decision has also been informed through work with a number of international project teams on issues significant to waste management and spent fuel. This included STUK, the Radiation and Nuclear Safety Authority of Finland; the United States Nuclear Regulatory Commission (NRC); and the Swedish Radiation Safety Authority (SSM). In September 2010 the Environment Agency and ONR participated in a meeting on radiation protection and waste management under the auspices of the Nuclear Energy Agency Multinational Design Evaluation Program (MDEP) EPR Working Group.

42 One area of our assessment is the design, layout and operation of the proposed UK EPR radioactive waste facilities. We arranged a series of joint benchmarking visits with ONR to international sites to improve our understanding of these facilities.

43 Benchmarking is a significant aspect of the assessment as radioactive waste can be affected by the decisions taken by the operators, irrespective of the basic plant

design. Benchmarking provides us with assurance that there are options that can be operated in a safe and environmentally acceptable manner.

44 EDF and AREVA assert that the necessary supporting information could be easily produced. They supported this assertion by arranging a number of site visits to show the processes in operation.

45 The EDF and AREVA GDA submission identifies a number of options for operating the UK EPR that are relevant to our assessment. However, we recognise that the future operator will choose the actual method of operation. To help substantiate the claims made about the different methodologies a number of site visits were arranged in France, Germany, Sweden, UK and USA. At these sites operation of waste management facilities, training and maintenance facilities, decommissioning activities, spent fuel pool operations and mobile plant were observed. We used the knowledge gained to inform our decision.

46 The visits were successful in establishing that different operational approaches can be successfully implemented. The relevant examples are referenced in our assessment reports. However these can be summarised into the following generic learning points:

a) There should be good segregation of liquid waste streams.

b) The discharge tanks should have some contingency.

c) Abatement systems need to reflect progressive discharge reduction.

d) Modern waste water reduction and abatement techniques can help reduce fresh water demands.

e) Flexible processing systems allow the plant to use best practice that is developed over its lifetime.

f) Space is needed in the waste management facilities to provide flexibility in dealing with the waste items a plant may produce over its operating life.

g) There is extensive experience of operating spent fuel **pools** with techniques well developed.

h) There is significant experience of operating spent fuel **dry stores** with techniques well developed.

i) Staged risk reduction based on pre-planned decommissioning stages is a good approach to decommissioning.

j) A plant's national/local circumstances (e.g. infrastructure availability, government policies, etc.) will influence the approach to waste management.

k) Waste processing and management is simpler if there is a defined end point.

l) Waste containers, their contents and the associated processes need to be shown to produce a product that can be disposed of.

47 More details of the different visits can be found in the assessment reports listed in Annex 3 of this Decision Document.

Liaison with ONR (and other bodies)

48 We have worked closely with ONR and its Technical Support Contractors throughout GDA including, where appropriate and effective, joint assessments, joint meetings with the RPs and joint site visits (as discussed above). This enables us to achieve the right balance between environmental, safety and security issues in relation to radioactive waste. We have considered ONR's GDA Step 3 and Step 4

reports (available at http://www.hse.gov.uk/newreactors/reports.htm). We have taken account of any relevant issues in our assessments detailed in this decision document.

49 We have also liaised with the Food Standards Agency (FSA) and the Health Protection Agency (HPA) on matters relating to the assessment of doses to members of the public. We have maintained contact with Natural England in light of its interest in the assessment of the impact on non-human species and with the Nuclear Decommissioning Authority (NDA) in light of its interest in the disposability of solid radioactive waste. We contacted these organisations as part of our consultation.

Final assessment reports

50 We have documented our detailed assessment in a series of assessment reports, which are listed in Annex 3. These are summarised in Chapters 5 – 14 of this document. The final assessment reports are revisions of the documents that we published to support the consultation. The updated final assessment reports reflect:

a) Our assessment of further information provided by EDF and AREVA since the consultation date.

b) Any further work that we said, in the consultation document, that we intended to do.

c) Any matters arising from ONR's GDA Step 4 work that are relevant to our assessment.

d) Our consideration of any consultation responses relevant to the topic.

Scope of GDA

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

52 The scope of what is included within our generic design assessments is dependent on the information supplied by the RP (remembering that GDA is a voluntary process, undertaken at the request of the RP). However, the required information for GDA needs to be sufficient in scope and detail to underpin the generic safety case for the design. Should there be omissions in that information that may jeopardize the completion of a meaningful assessment under the GDA process, then we insist on the scope of the submissions for GDA being expanded to include such essential information.

53 The GDA submissions should include the GDA Design Reference and the GDA Safety, Security and Environment Submissions. These documents and their control arrangements are listed below.

a) GDA Safety, Security and Environment Document Submissions.

b) GDA Design Reference and Design Reference Point.

c) Design Reference Change Control.

d) GDA Submission Quality Assurance Arrangements.

e) GDA Submission Consolidation.

54 One outcome from GDA is a commitment from regulators not to further assess at the site-specific stage of the project aspects of the safety case already assessed and accepted at the generic design stage. However, should the RP or operator (Licensee) later make either generic or site-specific safety, security or environmental significant changes that affect the basis of the GDA outcome, or if other significant information comes to light, then those aspects of the GDA submission may well require re-assessment by the regulators.

2.5.3 Consultation

55 The aim of the GDA consultation was to inform our assessment of new nuclear reactor designs by sharing information with people, and by listening to and using their input in our decision-making.[3]

56 It has always remained our responsibility to make decisions about the acceptability, or not, of a reactor design but we consider that our decisions are better informed through the consultation.

57 Our aim is to build and maintain confidence in our decision-making processes for GDA through our public involvement process, our consultation and our ongoing engagement.

58 We ran the consultation in accordance with the criteria set out in the Government's Code of Practice on Consultation (see Annex 6).

59 We published national and local engagement plans for GDA http://www.hse.gov.uk/newreactors/reports/stakeholder-engagement-plans.pdf.

60 We completed our consultation stage of our process, which ran from 28 June 2010 to 18 October 2010. We consulted widely so that people could bring any issues to our attention, see Annexes 6 and 7 of this document. Before this consultation, we did not make any final decisions, and did not do so until after we had carefully considered all the responses.

61 On 21 December 2010 we published a document that summarised the responses we received against the questions we asked (available at https://consult.environment-agency.gov.uk/portal/ho/nuclear/gda). It does not analyse or comment on the responses, which is undertaken in this document.

62 The key elements of our consultation - which was largely document based – are outlined below.

Consultation documents

63 We published two main documents, including an executive summary, one for each of the nuclear power plant designs – Westinghouse's AP1000, and EDF and AREVA's UK EPR. These were published on our website and hard copies were available, including Welsh bilingual versions. These included specific questions which we were seeking responses to.

64 To help the consultation process, we also included in the consultation document a draft interim statement of design acceptability for the UK EPR based on our initial (that is, before consultation) view.

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[3] 'Stakeholder engagement plan, Generic Design Assessment (GDA) of nuclear reactor designs', 2010, Environment Agency.

65 A series of detailed technical assessment reports were also published on the website and a non technical summary briefing note was produced for members of the public.

Responding on-line

66 To make the consultation as accessible as possible we made it available on our website and invited people to respond directly on-line.

67 Approximately 45% of people responded using our on-line tool. We are evaluating their experience so that we can learn lessons for future use and development of our on-line consultation tool.

Raising awareness and keeping people informed about the consultation

68 To raise awareness about the consultation and to encourage participation we:

a) Advertised the consultation in two local newspapers (one daily and one weekly) in each of the areas around potential new build sites that were included in DECC's draft Nuclear National Policy Statement.

b) Placed advertorials and secured editorial coverage in local authority magazines covering areas around potential new build sites, where possible and when available.

c) We regularly contacted people on our databases both nationally and also locally where sites were proposed. These databases include a wide range of organisations and individuals from parish and town councils to professional institutions and trade unions.

d) We wrote to a number of local stakeholders around proposed sites for new nuclear power stations to inform them about the consultation and to ask them how they would like to be engaged.

e) Issued press releases to national, regional and local media. The consultation gave rise to numerous items in the media – newspapers, radio and television and on-line.

f) Sent posters to libraries and other key locations in local communities.

g) Provided regular updates via the Regulators' (ONR and Environment Agency) joint eBulletin and quarterly report published on the Regulators' joint website.

h) Provided information on our website and the Regulators' joint website.

i) Distributed our Regulators' joint GDA leaflet.

j) Our communications and engagement activities were designed based on feedback from market research undertaken jointly by the Environment Agency and ONR in June 2009. http://publications.environment-agency.gov.uk/dispay.php?name=GEHO0709BQXA-E-E

Stakeholder meetings and events

69 We held a seminar on 6 July 2010, shortly after our consultation was launched to share the findings so far, respond to queries, gather initial views on the findings and on our ongoing stakeholder engagement process.

70 About 100 people attended from industry, NGOs, academia, local authorities and community groups and generated around 200 questions and comments.

71 We have considered all the views and questions recorded at the seminar in reaching our decision.

72 We participated in local community consultation events run by other organisations (for example, Department of Energy and Climate Change (DECC) and potential developers of new nuclear power stations) so that we could be asked and respond to questions on matters that we are responsible for.

73 We engaged with individuals and organisations for example from the nuclear academic community, Non-Governmental Organisations, industry and international Regulators.

74 We offered Site Stakeholder Groups and Local Community Liaison Councils around existing nuclear power plants, face to face briefings on our consultation.

75 Where possible, we gave presentations to groups that invited us to do so.

76 We took part in numerous nuclear new build seminars and conferences.

Public involvement process

77 The opportunity for people to access information about the reactor designs, submit comments and receive responses from the reactor designers, has also remained available throughout our consultation via our public involvement process. This process, designed for GDA, was launched in September 2007. It was primarily a website based activity available through the Regulators' joint website. We have encouraged the requesting parties to make it easier for people to access their design information. EDF and AREVA updated their website in Autumn 2009. The design information on its website has been updated at intervals and contains all the information provided to the Regulators except that which is commercially confidential or subject to national security restrictions.

78 To complete our assessment of the reactor designs by December 2011, we needed to receive any comments on the designs in sufficient time to reflect them in our Decision Documents (and ONR's Step 4 reports). Therefore, we have not considered any comments received through the current process after 31 December 2010.

79 However, we continue to run our public involvement process and people are able to email us at new.reactor.build@hse.gsi.gov.uk, or write to us at the following address:

Joint programme office
4S.2 Redgrave Court
Merton Road
Bootle
Merseyside
L20 7HS

80 Comments received about the public involvement process itself are addressed in a report published at the end of 'GDA Step 3' of ONR's assessment (HSE, 2009b).

Independent evaluation

81 We are publishing an independent evaluation of our consultation in Spring 2012. This will be publicised via the Regulators' joint eBulletin, joint quarterly report and published on the Regulators' joint website.

Additional information received since the consultation commenced

82 As noted in the Consultation Document, we expected to receive additional information from the RPs that could address our concerns and outstanding matters that we had raised. Additional information has been received to address concerns that we highlighted in the Consultation Document. We highlight in this Decision Document and the assessment reports where we have received additional information that has informed our decision on the acceptability of the UK EPR design. We also refer to the relevant part of the consolidated RP's submission (on the RP's websites) where the additional information may be seen.

83 When reviewing this additional information, we have also considered whether it should be made available to consultees so that they have an opportunity to consider it before our decision is made. We concluded that the additional information was not significant enough to require further consultation. In coming to this conclusion, we note that some matters will be subject to further consultation at the site-specific permitting stage (for example, site-specific discharge limit setting).

Consultation Responses and comments on the consultation process

84 We list the names of all the organisations that responded to the consultation in Annex 7 of this Decision Document. We have not given names of individuals or members of the public. The list gives a GDA number to each response (for example, GDA76 is for the Health & Safety Executive), so that this document can be searched to allow all respondents to see where their responses have been considered. Where we quote consultation responses in this document, we have not corrected spelling or grammar.

85 Other comments and questions were also raised at our seminar held on 6 July 2010 in Birmingham and these are recorded in the report of that day, which is available on the Regulators joint website – see http://www.hse.gov.uk/newreactors/seminar-060710.pdf.

86 Some responses raised comments about the consultation process. These are summarised below, with our response:

a) A member of the public (GDA119) commented '*Point 7 of your Executive Summary where you say the GDA focuses mainly on radioactive waste issues, implies a rather dismissive and complacent attitude to everything else… there is nothing here that hints at a 'fresh' approach or that you will ever question the underlying premise on which assumptions are made*.'

   We note that GDA is a new approach, working jointly with ONR to assess the designs and identify any concerns before the reactors are built. Our approach is also based on our learning from past experience, and the discharge and disposal of radioactive waste can be one of the most difficult and lengthy items in permitting / licensing new nuclear power plants; hence we guided RPs to develop a waste strategy based on avoidance and minimisation, and not to create orphan waste for which there is no disposal route. Furthermore, we have required the RPs to consider non-radioactive wastes and discharges, and these are considered in Chapter 14

b) The Nuclear Consultation Group (GDA149) stated ***'Good Practice Consultation**: The first pillar of the EU Aarhus Convention on 'Access to Information, Public Participation In Decision-making and Access to Justice in Environmental Matters' alms to ensure that the public is informed about the environment and their role in decision-making. Here, In order for the public to be able to invest trust in the governance of nuclear technology; consultation must be a truly involving process. In this context, the EA must clearly address all substantive issues raised by stakeholders and provide detailed responses. In doing so, the EA must interpret their role intelligently -for example, responses have included statements about rad-discharges and rad-wastes. The detailed rationale for these statements have been included by stakeholders in their submissions. Here, the EA must take on, and respond to, the questions raised by these statements.*

In other words, in order to overcome the widespread belief that institutions wishing to impose their arbitrary actions upon the public may be partial or secretive, all the key issues raised during the consultation must be explicitly, openly and transparently addressed by the EA. Any failure to do so would leave the Regulators and, hence, Government vulnerable to legal challenge and may lead to hostility and mistrust of any future energy policy decision.'

These principles are enshrined in the HMG Code of Practice on Consultations (www.bis.gov.uk/policies/better-regulation/consultation-guidance) which we are following for the matters within our responsibility and the criteria from which are included at Annex 6 of this Decision Document.

c) Greenpeace (GDA151) noted '*There are questions over the precise nature of this consultation and how the outcomes will be decided for the generic design assessment process which is not legally binding*.'

The regulatory basis of GDA is set out on Chapter 2.6 of this Decision Document

d) Greenpeace (GDA151) also noted '*EA should make clear exactly how this particular process fits in with other regulatory and policy making processes e.g. Nuclear national policy statement, Justification, HSE/NII GDA, and planning processes.*'

The Environment Agency's role is set out in Chapters 2.2 to 2.4 of this Decision Document. In October 2011, we also note DECC's Office for Nuclear Development published a revised timeline and commentary that shows in broad terms how the various workstreams in the new nuclear programme and other related activity fit together (see www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/new/new.aspx)

e) Greenpeace (GDA151) also stated '*The consultation, the first and last of its kind within the GDA process, overburdens the reader with information. It assumes access to documents (including computers and printers) as well as a level of knowledge this is unreasonable. As such it cannot be deemed a truly public consultation.*'

We acknowledge this is a technical consultation, and there is a lot of information. However, we aim to write our documents in a clear way with a format that allows people to access those elements that they are interested in. Our Consultation Document said we would do our best to respond positively to requests to attend meetings and other events to explain our findings, and where we received requests we have been able to respond. Consultees also ranged widely from those with very little knowledge of the subject to experts in their field. Therefore, the documentation was also tiered from short eight page summary documents, to the Consultation Document, supporting assessment reports and ultimately with links to the designs on the RPs websites.

87 The Nuclear Consultation Group (GDA149) and Greenpeace (GDA151) also raise a number of other concerns regarding our findings, and these are addressed at the appropriate point in Chapters 5 – 15 and Annex 8.

88 The HSE (now ONR) (GDA76) also responded to our consultation stating: '*Questions 1-9 all relate to the Environment Agency's regulation of the disposal and discharge of radioactive wastes from an EPR site. HSE's Nuclear Directorate is responsible for the regulation of on-site management of radioactive materials and there is thus a degree of common regulatory interest with regard to these matters. The close working relationship between the Nuclear Directorate (ND) and the Environment Agency means that we are familiar with the Agency's findings and areas of regulatory overlap have been the subject of discussion between our respective assessment teams. We therefore offer no comments in relation to these specific questions. However, our assessment work on the EPR generic design is continuing across all technical areas, and we cannot discount the possibility that issues may arise in relation to areas of common interest where ND and the Environment Agency may have differing views. Any such differences of opinion would be handled routinely as they arise as part of our established methods of joint working.*'

2.5.4 Post consultation review

89 We have acknowledged all the responses, but we did not generally enter into further correspondence with those who responded.

90 We have carefully considered each response that we received. Where issues arose that fell outside our responsibilities, we passed them to the appropriate Regulator, Government department or public body.

91 Where we needed advice from other organisations that have expertise on specific topics, we have sought the expert views of the Government department or official public body concerned, for example, the Radiation Protection Division of the Health Protection Agency – the Government's adviser on radiological protection. Similarly, if necessary, we have sought further information or clarification from the requesting party.

92 A number of responses to our consultation, and in particular to question 17, raised matters outside the scope of both GDA and our regulatory remit. These comments are summarised in Annex 8, with a short note as to why we are not considering them in our GDA. Examples include:

a) Site-specific concerns

b) Safety, security and transport matters

c) Government Policy or other Government Facilitative Actions

d) Matters associated with Planning

e) Matters associated with the development of a Geological Disposal Facility (GDF) and the Managing Radioactive Waste Safely (MRWS) programme.

2.5.5 Decision and statement

93 In the light of all the information obtained, including that received during and after our consultation, we have decided to issue an interim statement of design acceptability (iSoDA), which has two GDA Issues attached to it.

94 This decision document:

a) sets out the basis for our decision;

b) summarises the consultation responses and issues raised;

c) Explains how stakeholder input has informed our decisions and where stakeholder suggestions are not implemented, identifies why.

2.5.6 Environment Agency statement of design acceptability

95 Our iSoDA states our view on the acceptability of the design to be permitted, under the relevant environmental legislation, for:

a) the disposal of radioactive waste (gaseous, aqueous and solid);

b) the discharge of non-radioactive substances to water;

c) the operation of conventional plant (for example, combustion plant used as auxiliary boilers), where applicable;

d) the disposal or recovery of non-radioactive waste, where applicable;

e) the abstraction of water from inland waters or groundwater, where applicable.

96 Our view on the acceptability of the design with respect to the environmental requirements of the COMAH regulations is also being stated.

97 Although we have provided only an interim statement of design acceptability, we are confident that the UK EPR design is capable of being built and operated in the UK in a way that is environmentally acceptable. However, there are two GDA Issues that we want to see further progressed before ONR should consider providing Consent[4] to start nuclear island safety related construction.

98 The iSoDA refers to the GDA Submission (environment submissions and the Design Reference) as the basis of what has been included within the scope of GDA.

99 Our joint guidance with ONR on the Management of GDA Outcomes (Joint Regulators, 2010) sets out the different outcomes that are possible conclusions of GDA. Whilst we make separate decisions on the acceptability of the reactors, we are clear that we would require both the ONR Design Acceptance Confirmation (DAC) and our SoDA, to refer to the same Design Reference. We note ONR will be in a position to grant an interim DAC in December 2011 for the UK EPR with a number of GDA Issues requiring resolution by EDF and AREVA. As resolution of these GDA Issues may impact on matters relevant to our area of responsibility, and

[4] A Consent is required before the nuclear site licensee can carry out certain activities identified in the licence or other activities which ONR has the power to specify. For example, a Consent from ONR is required before a reactor is allowed to be started up again following a periodic shutdown. In order to secure a Consent the licensee must satisfy ONR that the proposed action is safe and that all procedures necessary for control are in place. See http://www.hse.gov.uk/nuclear/silicon.pdf

will lead to a revised Design Reference, we will only grant a full SoDA when the ONR GDA Issues are resolved, and we have considered any relevant impacts.

2.5.7 GDA Issues

100 A GDA Issue is an issue considered by Regulators to be particularly significant, but still resolvable. Where there are GDA Issues, the statement of design acceptability or design acceptance confirmation is labelled as 'interim', and the Regulators expect the RPs to produce a Resolution Plan that identifies how the Issue would be addressed. Our iSoDA has two GDA Issues attached to it.

101 In response to the GDA Issues, EDF and AREVA have provided detailed Resolution Plans that identify the details of how they intend to respond to the Issues. We have reviewed these Resolution Plans and discussed them with EDF and AREVA and we agree that they are credible. A credible Resolution Plan is one that provides persuasive arguments that the work proposed will be sufficient to satisfactorily address the GDA Issue, when considering the proposed scope of work, the deliverable descriptions, the timetable and milestone programme, the methodologies to be employed and the impact on the overall GDA submission documentation.

102 It should be noted however, that these Resolution Plans represent only one way of tackling each GDA Issue and EDF and AREVA may, in the end, choose another equally effective way of responding. Also, the Resolution Plans in no way represent a contract from the Regulators to complete assessment of GDA Issues within a particular programme, or to reach agreement on the matter.

103 The Resolution Plans are provided in full on our website: www.hse.gov.uk/newreactors.

104 If both ONR and our GDA Issues are addressed to each Regulator's satisfaction then the interim status of the SoDA will be reviewed and, if appropriate, a final SoDA and design acceptance confirmation (DAC) would be provided, together with reports describing the basis of the GDA Issue resolution. As noted above, only when all GDA Issues have been addressed to the satisfaction of the Regulators, will consideration be given to ONR providing Consent to start nuclear island safety related construction.

2.5.8 Assessment findings

105 As noted in our joint guidance with ONR on the Management of GDA Outcomes (Joint Regulators, 2010), the generic safety case that forms the basis of the GDA submission, will also inform any site-specific safety case. GDA was designed to assess the generic safety case for future reactor designs, and not the adequacy of the actual final design. It was also not intended to provide a complete assessment of the final reactor design, as there will be other issues, operator specific or site-specific, that we would expect to be considered during the environmental permitting and site licensing stages. In some instances the safety case can inevitably only be validated by procurement or later testing or commissioning. This validation process is normal regulatory business and will be subject to appropriate regulatory controls. Where we have identified findings of this type during our GDA assessment, we have highlighted them in this Decision Document. We would expect them to be addressed either by the designer or by a future operator / licensee, as appropriate, during the detailed design, procurement, construction, commissioning or early operational phases of the new build project.

106 In our Consultation Document, assessment findings were referred to as ‘other issues’. For clarity in this Decision Document the term assessment finding is used throughout.

107 We provide a consolidated list of our assessment findings in Annex 2 of this Decision Document.

108 Assessment findings are operator and site-specific and some cover areas already addressed by the standard conditions in the permits we would issue under the Environmental Permitting Regulations. They are included here for completeness and to ensure clarity for both prospective operators and members of the public to ensure a transparent and understandable handover from GDA to the site-specific permitting process. We acknowledge that some assessment findings may not be able to be fully addressed at the point of application for a permit, and may be dealt with by specific pre-operational conditions in the relevant permit.

109 We also note in the text where future operators will need to undertake specific tasks as part of the permitting of the site. Examples include:

a) Future operators will need to provide a detailed site-specific impact assessment for each site proposed. The site-specific assessment will need to be based on the actual environmental characteristics of the proposed site to demonstrate that doses to members of the public from the UK EPR at the proposed site will be as low as reasonably achievable (ALARA) and below relevant dose constraint and dose limits (see Chapter 13).

b) under the provisions of the Site Waste Management Plans Regulations 2008, future operators shall produce a site waste management plan for construction projects with an estimated cost greater than £300,000 (see Chapter 14).

As these are mandatory activities, we have not highlighted them as assessment findings.

2.6 Regulatory basis for GDA

110 The SoDA (or iSoDA) is provided as advice to the RP, under Section 37 of the Environment Act 1995, and has no other formal legal status. However, we will take full account of the work that we have done during GDA, in dealing with applications for environmental permits relating to a design that has been considered in GDA.[5]

111 The Environment Agency regulates several aspects of the operation of nuclear power stations in England and Wales. Previously, this was done under a number of regulatory regimes, but many of these have now been drawn together into a single permitting and compliance system known as 'Environmental Permitting'. (Further information on the Environmental Permitting Programme is available on the Defra website, http://www.defra.gov.uk/environment/policy/permits/index.htm.)

a) The disposal of radioactive waste requires a permit under *The Environmental Permitting (England and Wales) Regulations 2010* (EPR 10) (previously, an authorisation under *The Radioactive Substances Act 1993* (RSA 93) was required).

[5] Noting that at the we are currently determining applications by NNB Generation Company Ltd (NNB GenCo) for environmental permits for two UK EPR reactors at Hinkley Point in Somerset.

b) The discharge of aqueous effluents (such as from cooling or dewatering during construction) requires a permit under EPR 10 (previously, a consent under *The Water Resources Act 1991* (WRA 91) was required).

c) Some conventional plant (for example, combustion plant used as auxiliary boilers and emergency standby power supplies, and incinerators used to dispose of combustible waste) may require a permit under EPR 10.

d) The disposal of waste by depositing it on or into land, including excavation materials from construction, and other waste operations may require a permit under EPR 10 (before 1 April 2008, a permit under PPC 00 or a licence under Part II of *The Environmental Protection Act 1990* may have been required).

e) The abstraction of water (for example for cooling or process use) from inland waters or groundwater, except in some specific circumstances, requires a licence under WRA 91. Inland waters include rivers, ponds, estuaries and docks, amongst others.

112 The Environment Agency and HSE together form the competent authority for The Control of Major Accident Hazards Regulations 1999, Statutory Instrument 1999 No. 743 (COMAH 99). On-site storage of certain substances in large quantities may fall under these regulations.

113 Generation of radioactive waste is intrinsically linked to the detailed design of a reactor, together with its associated plant. We require generation of radioactive waste to be minimised, and so GDA has focussed on radioactive waste design issues. Permitting the disposal and discharge of radioactive wastes has also traditionally been the area of regulation that has had the longest lead time for our permitting of new nuclear power stations. Additionally, we have also looked at key aspects of the design relating to other areas such as abstraction and discharges to water, pollution control issues, and management of non-radioactive waste.

114 New nuclear power stations are likely to need new or enhanced flood defence structures. A flood defence consent will be needed to construct these but, as flood defence is necessarily site-specific, we have not considered this matter during GDA. ONR also considers flooding when assessing the safety of a nuclear reactor against external hazards.

2.7 The Fukushima accident

115 On 11 March 2011 Japan suffered its worst recorded earthquake. Reactor Units 1, 2 and 3 on the Fukushima Dai-ichi (Fukushima-1) site were operating at power before the event and on detection of the earthquake shut down safely. Within an hour a massive tsunami from the earthquake inundated the site. This resulted in the loss of all but one diesel generator, some direct current (DC) supplies and essential instrumentation, and created massive damage around the site. Despite the efforts of the operators eventually back-up cooling was lost. With the loss of cooling systems, Reactor Units 1 to 3 overheated. This resulted in several explosions and what is predicted to be melting of the fuel in the reactors leading to major releases of radioactivity, initially to air, but later by leakage of contaminated water to sea.

116 On 14 March 2011 the Secretary of State for Energy and Climate Change requested HM Chief Inspector of Nuclear Installations to examine the circumstances of the Fukushima accident to see what lessons could be learnt to enhance the safety of the UK nuclear industry.

117 The Environment Agency has a number of responsibilities relevant to the Chief

Inspector's report including our roles in flood and coastal risk management, providing advice to Government on potential new build sites, in emergency planning and incident response, and in the regulation of radioactive waste disposal, cooling water discharges, and stand-by generation plant. We worked with the ONR to help deliver the reports, and provided two formal submissions to ONR in response to a request for major issues and lessons for consideration in its reports.

118 The key impact on GDA is that, as we were waiting for any further extra lessons learnt from Fukushima to emerge in the Final Report, we did not believe it was appropriate to draw conclusions from our GDA assessment work in June 2011 as originally planned, nor publish our GDA technical assessment reports on that date. We and ONR decided to extend our GDA assessments to allow us to take account of the recommendations of HM Chief Inspector's reports.

119 HM Chief Inspector has now published his Interim and Final Reports (ONR, 2011a and 2011b) which identify the implications for the UK nuclear Industry and set out a number of recommendations for UK Government, the UK nuclear regulator and the UK nuclear industry to address. In total there are 38 recommendations, one which has been completed, four which are relevant to the nuclear regulator, which are relevant to the nuclear industry and nine which are generally relevant to the UK Government, the nuclear regulator and the nuclear industry. The final recommendation requires reports of progress responding to the recommendations to be made to ONR by June 2012.

120 In an international context there are a number of ongoing initiatives:

a) The European Nuclear Safety Regulatory Group (ENSREG) has defined a set of "Stress Tests" to be carried out in European Member States for Nuclear Power Plants (NPPs) in operation or being constructed. Each Member State will report the outcome of the "Stress Tests" by the end of December 2011, and these reports will be peer reviewed by an expert panel drawn from European Member States in early 2012.

b) The International Atomic Energy Agency (IAEA) has initiated a number of activities to draw lessons from the accident, assist the Japanese authorities and report to IAEA member states. These include:

   i) A preliminary mission to find facts and identify initial lessons to be learnt, undertaken by a team of experts from across the world, conducted from 24 May to 2 June 2011.

   ii) An IAEA Action Plan on Nuclear Safety, which is aimed at making nuclear safety post-Fukushima more robust and effective.

   iii) An Extraordinary Meeting of the Convention on Nuclear Safety (CNS) to share lessons learnt and actions taken in response to events at Fukushima, to be held in August 2012.

121 To ensure that the lessons learnt from the Fukushima accident are considered within GDA, we and ONR raised a further GDA Issue on EDF and AREVA to address any lessons to be learnt for the generic UK EPR reactor design. This requests EDF and AREVA to demonstrate how they will take account of the lessons learnt from the unprecedented events at Fukushima, both from those arising out of EDF and AREVA's own internal reviews, as well as those lessons and recommendations that are identified in HM Chief Inspector's Interim and Final Reports. These should also take account of the wider international initiatives.

122 EDF and AREVA has provided a Resolution Plan describing how they are addressing the recommendations. We consider that this Resolution Plan is credible. As EDF and AREVA progresses execution of its resolution plan, then, as

for the other GDA Issues, we will assess their progress on the plan and the results and outcomes of its actions to ensure that these are acceptable.

123 We will also continue to work with ONR and others on addressing relevant recommendation in HM Chief Inspector of Nuclear Installations' report, including those for regulators, and on longer term learning from Fukushima. For example, ONR are setting up a joint advisory group with the Environment Agency and SEPA to advise on the industry's reviews of flooding studies, and we are also involved in the national Nuclear Emergency Planning Liaison Group in its work to review our national arrangements in the light of learning from Fukushima.

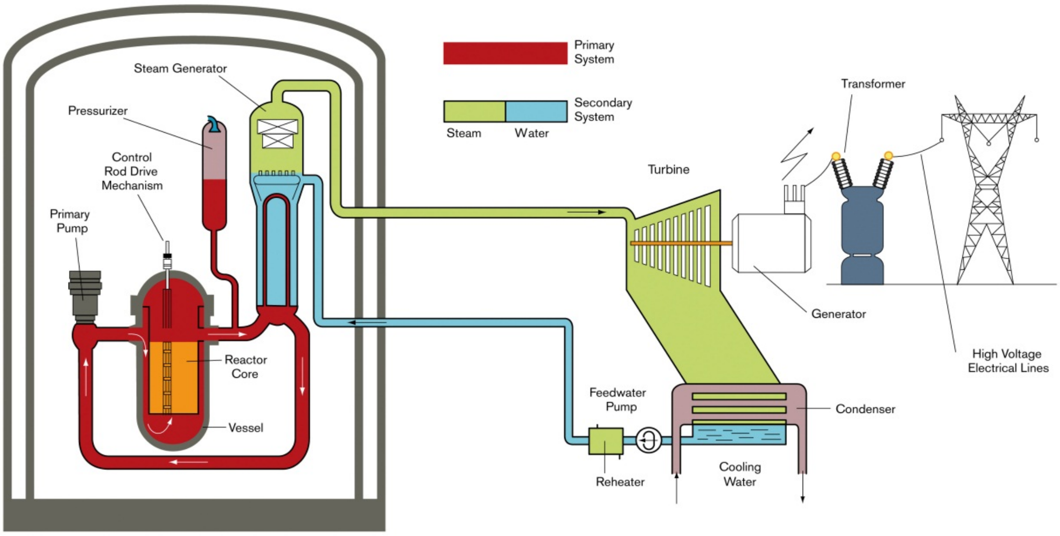
3 The UK EPR design

124 EDF and AREVA submitted the UK EPR design for GDA. The UK EPR uses the AREVA EPR™ reactor with AREVA AFA 3GLE fuel assemblies. This section provides a brief outline of the UK EPR design and how it is proposed that waste will be created, processed and disposed of.

125 There were some queries raised at our stakeholder seminar about the relationship of the UK EPR to the EPRs being built in Olkiluoto, Finland and Flamanville, France. These projects use the AREVA EPR™ reactor and the design of this reactor is essentially standard. However, any power plant design may have some differences to allow for its location, in particular different countries have differing regulatory requirements. For the UK, EDF and AREVA chose the overall design of the Flamanville 3 plant as the '*reference plant*' but the UK EPR will have some differences to meet UK requirements and regulations. Flamanville 3 is still under construction so that information on waste disposals in this document is based on design estimates based on operational experience of the French nuclear fleet of PWRs rather than actual arisings. However, both Olkiluoto and Flamanville 3 should be operational before any UK EPR and their operational data will be used to refine the estimates.

3.1 Outline of design

126 The UK EPR design is for a single, pressurised water reactor (PWR) capable of generating in total 1735 megawatts (MWe) of electricity and providing 1630 MWe of this to the national grid. In the reactor core, the uranium oxide fuel (enriched up to 5 per cent of uranium-235) is cooled by water in a pressurised circuit, the primary circuit. This water also acts as the neutron moderator necessary for a sustained nuclear fission reaction. The primary circuit includes four steam generators where heat is transferred from the primary circuit to an isolated secondary circuit, producing steam. This steam then drives a turbine-generator to produce electricity, is condensed, and the condensate returned to the steam generators.



Simplified schematic of the EPR™ reactor (source AREVA)

127 The main ancillary facilities include a spent fuel pool, water treatment systems for maintaining the chemistry of the primary and secondary water circuits, standby diesel generators for providing power in the event of loss of grid supplies, and waste treatment and storage facilities. For GDA purposes, turbine condenser cooling water is provided by a once-through system using seawater.

128 The UK EPR design has evolved from combining experience from earlier separate PWR designs operating in France and Germany (77 operational plants). The most recent French design was the N4, brought into commercial operation in 1996 (Chooz B1). The most recent German design was the KONVOI, brought into commercial operation in 1989 (GKN-2). The EPR™ has undergone design assessment by the nuclear Regulators in Finland and France and has obtained construction licences. Four EPR plants are already being built: one at Olkiluoto in Finland; another one at Flamanville in France; and two at Taishan, China. Certification of the EPR reactor design is currently underway in the USA, where a number of power companies have chosen the EPR reactor for their new generation construction projects.

3.2 Sources, processing and disposal of radioactive wastes

129 Radioactive waste would be produced by 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 substances in the water of the primary coolant circuit, which subsequently become waste.

130 Discharges of radioactive waste dissolved or carried in water (aqueous discharges) are produced mainly from effluents associated with systems for treating the primary circuit water or with drain systems. Other sources of effluent include the fuel pool purification system and washings from plant decontamination. Effluent treatment facilities include accumulation, hold up and monitoring tanks; filters; evaporation; degassing and demineraliser ion exchange resin beds. Facilities to sample and monitor aqueous waste before it is released are provided. Final discharge is to the sea combined with the cooling water.

131 The main source of gaseous radioactive discharges is from degassing the water in the primary circuit. This is directed to the gaseous effluent treatment system where waste gas is dried then passed through a line of three activated carbon delay beds (to allow noble gases to decay). After primary filtration, the waste gas is further filtered through high efficiency particulate air (HEPA) filters and iodine traps, if necessary, before being discharged after sampling and monitoring.

132 Gaseous activity will also be present in the main process buildings, which are serviced by the heating, ventilation and air-conditioning (HVAC) systems. Extracted air is passed through HEPA filtration systems and, if necessary, iodine traps before being discharged. There is also the possibility of radioactivity, particularly tritium, reaching the secondary circuit due to minor leaks from the primary circuit. Gases collected in the condenser vacuum system of the secondary circuit are directed to the HVAC system for HEPA filtration. All gaseous waste streams are collected for discharge through a common stack. Stack height is based on site-specific factors to give good dispersion, as a minimum it will be at the height of the reactor building (60 m). There is provision for sampling and monitoring gaseous wastes at various points in the treatment systems as well as at the final combined discharge stack.

133 Other radioactive waste created by the UK EPR includes spent ion exchange resins; spent filter media; worn-out plant components and parts; contaminated protective clothing and tools; rags and tissues and waste oil. These are collected in the solid waste treatment plant where basic conditioning is carried out so they can be disposed of off-site. Intermediate level waste (ILW) will need to be stored until disposal facilities are available.

134 EDF and AREVA do not expect that the UK EPR plants will generate any novel solid waste streams. Solid low level radioactive waste (LLW) from its operation will be suitable for disposal at the UK national LLW repository near Drigg in Cumbria.

135 Most radioactive plant components are likely to become waste when the plant is decommissioned. The strategy for disposing of decommissioning waste is described later in this document.

136 Spent fuel will be stored under water in the spent fuel pool for some years. The options for longer term management are described later in this document.

3.3 Non-radioactive waste

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

a) combustion gases discharged to air from the diesel generators;

b) water containing water-treatment chemicals from the turbine-condenser cooling system; other non-active cooling systems and the secondary circuit purge, which is discharged to the sea;

c) waste lubricating oils;

d) screenings from sea inlet filters;

e) worn-out plant and components and general rubbish.

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

4 Guide to our detailed assessment

139 In the following chapters (5 -14), we set out our conclusions:

a) Management Systems (chapter 5);

b) Radioactive Substances Regulation

   i) Integrated Waste Strategy (chapter 6)

   ii) Best Available Techniques to minimise production of radioactive waste (chapter 7)

   iii) gaseous radioactive waste disposal and limits (chapter 8)

   iv) aqueous radioactive waste disposal and limits (chapter 9)

   v) solid radioactive waste (chapter 10)

   vi) spent fuel (chapter 11)

   vii) monitoring of radioactive disposals (chapter 12)

   viii)impact of radioactive discharges (chapter 13);

c) other environmental regulations (chapter 14).

140 The detailed assessments provided in Chapters 5 – 14 are essentially the same as those provided in the consultation document but updated, where appropriate, to reflect:

a) Our assessment of any further information provided by EDF and AREVA since the consultation date.

b) Any further work that we said, in the consultation document, that we intended to do.

c) Any matters arising from ONR's GDA Step 4 work that are relevant to our assessment.

d) Our consideration of any consultation responses relevant to the topic.

141 Our assessments:

a) identify any matters that would be GDA Issues attached to our statement of design acceptability. These GDA Issues may be due to:

   i) EDF and AREVA failing to provide enough information for our assessment (for example, because an aspect of the design is not complete);

   ii) a technical issue raised by our assessment not being fully resolved or confirmed.

b) identify any assessment findings that would need to be cleared at an appropriate point during the reactor procurement, detailed design development or construction programme. The assessment findings may relate to:

   i) matters that are normally addressed during the construction, commissioning, or early operational phase of a plant (for example, demonstration that as-built plant realises the intended design);

   ii) matters that depend on site-specific characteristics.

142 We referred to 'other issues' in our consultation document, but with ONR we decided a better description was 'assessment finding' and this matches the ONR terminology. The meaning of either description is essentially the same but the assessment findings have been updated following consultation.

143 Our detailed assessment took account of the legal and policy issues set out in our considerations document (Environment Agency, 2009c), where practicable at the generic level. Our considerations document was superseded with the introduction of the Environmental Permitting Regulations (EPR 10) in April 2010 and the issue of related guidance documents. We have reviewed our assessment against the EPR 10 guidance to reach our decision.

144 As part of our agreed GDA process with the requesting parties we agreed a mechanism for raising concerns and / or requesting further information. This mechanism works on a tiered approach depending on the severity of our concern:

a) **Technical Query** (TQ): These were the means by which we routinely sought clarification or further technical information from the Requesting Party. Typically this might be a request for supporting documentation or other clarification of claims or arguments made by a Requesting Party in their safety case. A Technical Query may well have resulted in a Regulatory Observation or Regulatory Issue being raised where the query cannot be satisfactorily resolved.

b) **Regulatory Observation** (RO): We used Regulatory Observations to bring significant assessment matters to the attention of a Requesting Party, to highlight that further justification was required. Regulatory Observations were supplemented by one or more actions which set out our expectations for the work required for a satisfactorily resolution. Their response was then the subject of further assessment by the Regulators.

c) **Regulatory Issue** (RI): We used Regulatory Issues to identify matters that we considered were of sufficient importance that they may, if not resolved, prevent the successful completion of GDA. Regulatory Issues were supplemented by one or more actions which set out our expectations for the work required for a satisfactorily resolution. Their response was then the subject of further assessment by the Regulators.

145 We found that the initial submission did not contain the level of information we needed to carry out a detailed assessment. We raised a Regulatory Issue on EDF and AREVA and they committed to providing further information. EDF and AREVA provided a completely revised submission, their '*pre-construction environmental report*' (PCER) with supporting documents. They have published the PCER and other documents on their website (http://www.epr-reactor.co.uk).

146 During our assessment of the PCER, we had some concerns and needed some additional information. We raised 4 ROs and 33 TQs on EDF and AREVA, some of which were joint with ONR. In addition we collaborated with ONR in some of the ROs and TQs they raised. We assessed the information provided in all relevant ROs and TQs in reaching our decision. The responses to these ROs and TQs were incorporated into revisions of the PCER and some additional supporting documents, as now available on the website noted above. We published the preliminary conclusions of our detailed assessment in June 2010 in our consultation document.

147 We consulted on the outcome of our detailed assessment of the information contained in the revised submission. The documents comprising the submission were listed in Annex 5 of the consultation document (now to be found in Schedule 1 of Annex 1 of this document). Some documents were revised after consultation, we reference most frequently to the following documents in our decision document and have noted which documents have been revised:

a) Pre-construction environment report (PCER)(revised);

b) Pre-construction safety report (PCSR)(revised);

c) GDA UK EPR integrated waste strategy document (IWS);

d) GDA UK EPR BAT demonstration (EPRB);

e) UK EPR solid radioactive waste strategy report (SRWSR).

f) UK EPR Reference design configuration (revised).

148 More details of our assessment can be found in our assessment reports. These are listed in Annex 3.

149 The White Paper on Nuclear Power (BERR, 2008a, paragraph 2.87) states that: '*The environment agencies will ensure that radiation exposure of members of the public from disposals of radioactive waste, including discharges, are as low as reasonably achievable (ALARA) by requiring new nuclear installations to use the best available techniques (BAT) to meet high environmental standards. This will help ensure that radioactive wastes created and discharges from any new UK nuclear power stations are minimised and do not exceed those of comparable power stations across the world.*'

150 Annex 4 of this decision document presents an analysis of discharge data from predecessor nuclear power stations, so that we can make a comparison with the predicted discharges from the UK EPR. However, it is important not to draw comparisons too closely as there are many uncertainties in the datasets. For example, the published results:

a) are the results of measurement - albeit to differing standards, or are derived from calculations of predicted discharges;

b) treat limits of detection in different ways;

c) are taken from reports in differing formats; and,

d) should not be compared with other data without establishing how those were obtained and reported, for example Germany only requires the measuring and reporting of carbon-14 in the carbon dioxide form.

151 The public involvement process has been available throughout our assessment. We addressed those comments we received before 4 January 2008 in our preliminary assessment report. We have considered comments we received since then until the end of 2010 during our detailed assessment, and refer to these in the relevant sections of Chapters 5 – 14.

152 We set out our decision on design acceptability in Chapter 15.

5 Management systems

5.1 Conclusions

153 Our conclusions remain unchanged since our consultation. However, they are subject to a GDA Issue, see 5.2 below.

154 **We conclude that EDF and AREVA have an appropriate management system in place to:**

a) **control the content and accuracy of the information provided for GDA;**

b) **maintain records of design and construction;**

c) **control and document modifications to the design.**

155 **We conclude that EDF and AREVA have adequately specified:**

a) **their expectations for any operating utility's management system;**

b) **how they expect to transfer knowledge and provide continuing support to any operating utility**.

5.2 GDA Issue

156 Our conclusions are subject to a GDA Issue joint with ONR, which will need to be resolved by the proposal and implementation of a satisfactory resolution plan by EDF and AREVA. This reflects that EDF and AREVA will need to continue to control changes to GDA submission documents, resulting from the management of design changes, until the issue of final design acceptance confirmation / statement of design acceptability from the Regulators.

157 The GDA Issue is:

a) Provide a consolidated Final GDA Submission, including agreed design change for the UK EPR: EDF and AREVA to continue to control, maintain and develop the GDA submission documentation, including the Safety, Security and Environmental Report (SSER), Submission Master List (SML) and design reference document and deliver final consolidated versions of these as the key references to any DAC/SoDA the Regulators may issue at the end of GDA. These should include the management and acceptance of changes to GDA submission documentation impacted by design changes agreed for inclusion in GDA. (GI-UK EPR-CC02)

5.3 EDF and AREVA's management system

158 We examined EDF and AREVA's management system in some detail during our preliminary assessment in 2007-8 and concluded that it was suitable for controlling the content and accuracy of the information EDF and AREVA had provided to us for GDA (Environment Agency, 2008a). There were, however, some matters that we felt could be improved and we made recommendations for improvement during our Regulators' inspection in 2007 for EDF and AREVA to consider.

159 EDF and AREVA responded positively to the recommendations of the Regulators' inspection of December 2007, and have implemented changes to reflect the suggested improvements.

160 During the detailed assessment stage, we kept EDF and AREVA's management arrangements under review. Our assessment of management arrangements involved reviewing EDF and AREVA's GDA submissions and arrangements for quality management, in particular the overarching project quality assurance plan (PQAP) produced by the joint project team, established by the two co-applicants EDF and AREVA. The PQAP describes the detailed arrangements in place to produce the GDA submissions for the UK EPR design, including the PCER and PCSR, and for the development of responses to Regulatory Issues, Regulatory Observations and Technical Queries issued by the Regulators, and for responding to the public involvement process.

161 The PQAP is supported by the quality and environment management systems of the co-applicants and their sub-contractors. The management systems comply with internationally recognised standards and are externally audited.

162 AREVA's organisation changed in 2010 during GDA and supporting information was provided to the Regulators. AREVA's existing integrated management system continued to apply to the new organisation during the transition period. The GDA submission documents (PCSR Chapters 21.1 and 21.2, PCER Chapters 2.1 and 2.2) were updated to provide information on the new organisational structure and interfaces.

163 One respondent (GDA123) to our consultation queried '*what standard is each management system based on….Have the management systems been third party assessed by a recognised accreditation body?*'.

164 Information is provided in the PQAP (revision 4, 2011) to indicate that EDF and AREVA management systems applied to the UK EPR project comply with international standards, for example ISO 9001 (2008) Quality Management Systems - Requirements. There are external audits carried out, including assessments by recognised accreditation bodies. This information has been discussed with the Regulators during the GDA inspections, and QA topic meetings, and the inspection reports are available on the joint website.

165 The PQAP is supported by a number of joint project instructions and procedures that were specifically developed for the UK EPR GDA project. These include arrangements for control of documents, data and records, design change, management responsibility, and resource management. The PQAP was revised throughout the GDA project to reflect developments in the project organisation and associated documents and instructions, most recently in March 2011.

166 One of the consultation responses in regard to management systems expressed concern due to the involvement of two companies. Maldon Town Council (GDA51) commented '*we note that AREVA EDF have demonstrated that they understand the requirements, but not convinced that they can be put into place due to 2 companies involved*'.

167 The Institution of Mechanical Engineers (GDA145) suggested the involvement of the two companies as co-applicants may provide benefit to the transfer of knowledge. '*The Institution considers that EDF and AREVA as co-applicant requesting parties with EDF as a potential operator should be a benefit to the transfer of design information and establishment of a learning organisation. We are content that AREVA and EDF have set out sufficient and well proven management systems to provide quality control during the design phase with well established*

plans to transfer the knowledge from vendor to operator during the plant handover stage'.

168 Inspections were carried out by the Regulators during GDA which examined the interfaces and arrangements between the co-applicant organisations for the UK EPR project. We were satisfied with the interfaces and joint project arrangements. Our expectations for the future operators management system are set out later, together with our findings on the arrangements for knowledge transfer between the vendor and future owner / operator.

169 The Institution of Mechanical Engineers (GDA145) also commented '*notwithstanding that GDA is for a single reactor power station, the Institution considers the assessment document should include a statement regarding the suitability of the management systems proposed for twin reactor stations'*.

170 EDF and AREVA applied for GDA against a single UK EPR reactor, and our assessment was mainly around EDF and AREVA's ability to manage the design in GDA. While a twin reactor station is proposed by NNB Genco Ltd at Hinkley Point C, and, as such, the management system proposed in the operator's arrangements will be assessed to determine if it is appropriate for this proposal.

171 The Regulators carried out a further inspection during the detailed assessment stage of GDA in April 2009. This was followed by a quality assurance topic specific meeting in July 2009. The inspection focused on:

a) the arrangements for controlling modifications to the UK EPR design;

b) configuration control for GDA submission documents and arrangements for transmitting submission documents to the Regulators;

c) internal, external and third party certification audits;

d) learning from experience; and

e) procurement arrangements.

172 Procurement of long lead items was subsequently agreed to be out of scope for GDA.

173 The Regulators made a number of recommendations that they discussed with EDF and AREVA during the 2009 inspection. The Regulators' inspection report was published in 2009 and can be found at http://www.hse.gov.uk/newreactors/reports.htm.

174 The Regulators' conclusion from the inspection was that:

a) EDF and AREVA continue to manage and operate joint activities in support of GDA in a professional way.

b) These joint activities are defined in the UK EPR project quality plan and are implemented through the related procedures.

c) The joint project arrangements are supported by well-established quality management systems operated separately by EDF and AREVA.

d) There were no major issues identified during the joint inspection and so the Regulators have confidence in EDF and AREVA's GDA project arrangements.

175 We issued two Regulatory Observations following our April 2009 inspection. We raised a number of aspects for EDF and AREVA to consider, including clarifying the role of the independent nuclear safety assessment process (INSA) as applied to design changes, and its application to environmental aspects of the design (RO-EPR-34).

176 The inspection suggested that EDF and AREVA should consider extending auditing programmes to cover all UK GDA support contractors. The joint inspection team also suggested that both EDF and AREVA should consider reviewing their current arrangements for managing and tracking non-conformances from their auditing activities (RO-EPR-31). The Regulators consider it would be beneficial to develop integrated systems:

a) for capturing non-compliances;

b) for tracking processes that would provide improved management information to support close outs and system improvements and strengthen the well being of the management system.

The joint inspection identified that further discussions were needed on issues including submission tracking sheets, design change controls and INSA arrangements.

177 The Regulators and EDF and AREVA held a quality assurance topic specific meeting in July 2009. There was further discussion on the inspection recommendations including RO-EPR-31 and RO-EPR-34 and the proposed responses from EDF and AREVA.

178 In regard to RO-EPR-31, the evidence provided and discussions held satisfied the Regulators that AREVA has an integrated oversight and review process in place for its quality assurance audit activities. The Regulators considered the responses from EDF and AREVA provided enough information and were satisfactory. The closure of RO-EPR-31 on arrangements for tracking and closure of non-conformances from audits was agreed in September 2009.

179 EDF gave commitments to complete further actions in auditing arrangements and implementing associated learning by the end of 2009. This is an area that ONR examined again in Step 4 during planned inspections in April and September 2010. We continued to work closely with the ONR and the findings from ONR's inspections were used to inform our decision for GDA, see below.

180 RO-EPR-34 on INSA was discussed in the quality assurance topic meeting in July 2009. The rationale had been to only apply INSA to parts of the submission produced uniquely for UK GDA. It was confirmed, as understood by the Regulators' inspection of December 2007, that INSA was applied to Volume 1 of the Safety Security and Environment Report; that is the initial GDA submission made in 2007, including Chapter G on Environment.

181 We have assurance from evidence reviewed and discussions held in July 2009 that an independent peer review process has been applied to producing the PCER. A number of report reviews related to the PCER were requested and examined during the July meeting.

182 EDF and AREVA formally responded to provide a summary of information discussed at the July meeting, and proposals for application of independent peer review for future PCER submissions made during GDA. The Regulators were satisfied with the review arrangements that had previously been applied to GDA documents on the basis of evidence seen in the inspection, and further topic meeting. The Regulators were also satisfied with the plans for future reviews that were formally documented in revised versions of project instructions. The closure of RO-EPR-34 was agreed in August 2009.

183 EDF and AREVA responded to those recommendations that were raised following the Regulators' inspection in April 2009. We are satisfied that their responses fully address the issues we raised. The implementation of EDF and AREVA's

responses to the inspection recommendations were examined during ONR's planned Step 4 inspections, and were generally found to be satisfactory.

184 In its Step 4 report, ONR found that internal audit actions were managed appropriately (ONR, 2011d), and concerns raised in regard to the management of non-conformances from supplier audits were satisfactorily addressed by EDF and AREVA during step 4. A number of assessment findings were raised by ONR and are required to be addressed by the future licensee. We will expect the future operator to address such matters as part of their management arrangements at the site-specific stage.

185 We conclude that EDF and AREVA have an appropriate management system in place to:

a) control the content and accuracy of the information provided for GDA;

b) maintain records of design and construction;

c) control and document modifications to the design.

186 Some consultation responses from individual respondents and learned societies supported our preliminary conclusions on management systems: *'I accept the value of your preliminary conclusions on management systems'* (GDA25). *'The conclusions on AREVA/EDF management and information exchange systems appear robust and relevant'* (Institution of Chemical Engineers, GDA67).

187 A individual respondent (GDA84) commented that they were happy with our preliminary conclusions on EDF and AREVA management systems and noted '*Clearly the two companies have a unique combination of complementary expertise and have taken all the preliminary comment on board'*.

188 Horizon Nuclear Power (GDA127) responded that it '*agrees that the Environment Agency has been rigorous in reviewing EDF and AREVA's management systems. We agree with the high expectations identified by the Environment Agency for EDF and AREVA's management systems*.'

5.4 Ongoing work since our consultation proposals were published

189 ONR have continued to assess EDF and AREVA management systems in its Step 4 of GDA. We have continued to work closely with ONR, and we reviewed new information on management systems and participated in selected meetings with EDF and AREVA and ONR. More details are presented below and in our final assessment report on management systems that has been updated since our consultation with further information.

190 A number of consultation responses were received in regard to management systems, and these have been addressed in this document. These responses have been shared with ONR since this is an area where we have worked closely together as we have joint regulatory responsibility. Related questions were also raised and published from our 6 July GDA stakeholder seminar and are considered. http://www.hse.gov.uk/newreactors/seminar-060710.pdf

191 HSE (now ONR) responded to our consultation (GDA76) to note the degree of common regulatory interest with regard to our consultation questions, including management systems. ONR had no comments in regard to our specific consultation questions as these are areas where we have had ongoing interaction and discussions between assessment teams in ONR and Environment Agency.

192 ONR carried out a further inspection of EDF and AREVA on procurement arrangements in Step 4 in April 2010. The scope of the inspection was procurement arrangements for delivering the design presented in the GDA submission including the PCSR.

193 ONR carried out further planned inspections in Step 4. The inspection findings are discussed in ONR's Step 4 report on the Management of Safety and Quality Assurance (MSQA) (ONR, 2011d) and in this document where relevant to our decision.

5.4.1 Management of Design Changes during GDA including changes to the Design Reference Point (DRP)

194 One of the questions raised at our GDA Stakeholder Seminar in regard to management systems was '*Once the design is approved to what extent is the design frozen?*'. EDF and AREVA are required to submit a design reference point (DRP) as the basis for GDA; effectively the design is frozen at the time of the DRP. All GDA submissions made to the Regulators should be based solely on that defined design. Supporting procedures are in place for DRP and changes to the DRP for GDA can only be made by submission to the Regulators Assessment Review Group (ARG).

195 As a general principle, EDF and AREVA wish to keep the UK EPR design as close as possible to the Flamanville 3 (FA3) design, that is the reference design. The design freeze was established at December 2008. The GDA UK EPR design reference is described in UKEPR-I-002 'Reference Design Configuration'.

196 Ingleby Barwick Town Council (GDA38) raised the issue of management of design changes in its response to our consultation ' *checks need to be made following design modifications. Problems must not slip through the safety net*'. Also, Cumbria County Council (GDA166) commented '*AREVA/EDF intention to "optimise" EPR construction in the UK in the light of experience at Olkiluoto, Finland and Flamanville, France suggests the EPR design information assessed by the Joint Regulators could be subject to change. The EA is asked to explain how the joint Regulators plan to manage the continuing generic assessment process for an evolving reactor design'*.

197 There is a process for changes in design, resulting from design improvements or regulatory requirements, to be taken into account during GDA; this is described in more detail below.

198 ONR wrote to EDF and AREVA outlining its six step change control process, for consideration of design changes for inclusion in Step 4 of GDA. EDF and AREVA are required to notify the Regulators of the proposed design change, and the rationale and description for the design change, and to provide confirmation of the design change categorisation and impact assessment.

199 EDF and AREVA's project instruction on design change for GDA UKEPR-I-003 defines the design change control process for the UK EPR during GDA. Proposed changes are specified using the UK EPR Reference Design Configuration as the baseline. The instruction mirrors the ONR six step change process, with a three stage design change categorisation process using A1, A2 and B categories based on impact of the change on the GDA submission. A1 and A2 changes are modifications related to nuclear safety, environment and security; A1 changes have, or potentially have, a significant impact, while A2 changes have a minor impact in regard to GDA submissions. Category B changes are not related to nuclear safety, environment and security.

200 The proposed changes to the design are considered by the Regulators Assessment Review Group (ARG). The Regulators then provide formal agreement (or not) in writing to EDF and AREVA in regard to inclusion of the change proposal in GDA. The Regulators have agreed to include some design changes in GDA to address regulatory queries arising from our assessment, for example for control and instrumentation systems to be included.

201 Design changes considered for inclusion in GDA may be from Flamanville 3 (FA3) changes proposed for inclusion by the RP or changes specific to UK EPR addressing issues arising from the Regulators' assessments.

202 An inspection on design development was carried out by ONR in September 2010. ONR found well established arrangements in EDF and AREVA for design development, design change control and configuration control. Two inspection recommendations were made as the scope of the project specific procedure for managing design changes within GDA was found to be limited.

203 The inspection recommendations were identified in a regulatory observation RO-UKEPR-81 containing two actions in October 2010. One action was for a process to be developed and documented for identification, control, review and acceptance and implementation of changes to all supporting documentation for design changes to be included in GDA. A second action required a process to be developed and documented by EDF and AREVA for transferring the information associated with incomplete design changes from GDA to phase 2 site-specific.

204 EDF and AREVA updated their design change procedure in response to RO-UKEPR-81 to provide further detail of the processes to be applied for managing design changes. The revised procedure includes new sections on management of UK specific changes originating from the Regulator's assessment, and a section on management of changes post GDA. It also includes the transfer of incomplete design changes agreed for inclusion in GDA to phase 2 site-specific activities.

205 A meeting was held between EDF and AREVA and the Regulators in September 2010 where proposals for incorporation of design changes from FA3 were presented. A proposal was made by EDF and AREVA to update the UK EPR design reference point to end 2010, to include design changes originating from FA3, in Design Freeze 2010, DF2010.

206 However, although the Regulators have agreed to sample the FA3 originated changes proposed for DF2010, these have not yet been agreed for inclusion in GDA.

207 The ARG agreed in principle to the update to the GDA Design Reference post Step 4 to include FA3 design changes, subject to ONR and Environment Agency:

a) Agreeing a programme with EDF and AREVA for the submission of information for each design change to be considered, including description, impact assessment and justification for the proposed design change categorisation.

b) Developing an appropriate sampling process for FA3 design changes.

c) Developing a process for acceptance / rejection of sampled design changes in GDA.

208 We participated in ONR's MSQA convergence meeting for Step 4 with EDF and AREVA on 27 October 2010. We discussed with EDF and AREVA that we might raise an issue in regard to design reference, which is proposed to change to Design Freeze DF2010, since this will be the reference for any final Statement of Design Acceptability we might issue for the UK EPR. Our consultation on our preliminary conclusions for the UK EPR was based on the design described in the 2008 design freeze. We require that a description of any proposed design change to be

incorporated in DF2010 is clear and explicit regarding the impact of the proposed change on the environment, and that an appropriate impact assessment has been undertaken and affected documents such as the PCER have been clearly identified.

209 EDF and AREVA will produce a consolidated PCSR and PCER in 2012 that will include all changes to reflect the revised DRP.

210 It is our expectation that EDF and AREVA will continue to control, maintain and develop the GDA submission documentation including the SSER, SML and design reference and deliver final consolidated versions of these documents as the key references to any SoDA we may issue, and DAC that ONR may issue at the end of GDA. These should include the management and acceptance of changes to GDA submission documentation impacted by design changes agree for inclusion in GDA.

211 EDF and AREVA shall ensure that these key deliverables are subject to appropriate review and that the review comments are included, as appropriate, in the final consolidated submission.

212 This is the basis for our GDA Issue, jointly with ONR 'Consolidated Final GDA Submission, including agreed design change for the UK EPR'. Our conclusions are subject to this GDA Issue which reflects that EDF and AREVA will need to continue to control changes to GDA submission documents, resulting from the management of design changes, until the issue of final design acceptance confirmation/statement of design acceptability from the Regulators.

213 The GDA Issue has three actions:

a) EDF and AREVA to fully implement its processes to manage the implementation and acceptance of amendments to documentation impacted by design changes agreed for inclusion in GDA, including any other additionally agreed design changes associated with other GDA Issues Resolution Plans. This should involve the incorporation of all relevant amendments into the impacted documentation associated with design changes, including the Reference Design Configuration Document UKEPR-I-002, the PCSR and the PCER.

b) EDF and AREVA to apply the revised Design Change procedure in order to identify and transfer all relevant agreed incomplete GDA design changes into Nuclear Site Licensing and permissioning activities, and Environmental Permitting.

c) EDF and AREVA shall continue to control, maintain and develop the GDA submission documentation, including the SSER, SML and design reference document and shall deliver final consolidated versions of these as key references to any DAC / SoDA we may issue at the end of GDA.

214 The scope of design changes included in this GDA Issue includes those incomplete design changes already agreed for inclusion in GDA and any additional design changes arising as part of the Resolution Plans associated with other ONR GDA Issues.

215 During the site-specific phase, further design changes may be proposed for the UK EPR design as a result of learning from experience on EPR construction projects. ONR raised an assessment finding in their Step 4 report for the future licensee to manage and control design changes as a result of learning from experience during construction. We would expect the future operator to have appropriate arrangements in place to control and manage such design changes at the site-specific stage.

5.5 General consultation responses

216 We consider consultation responses made in regard to specific issues such as management of design changes in the relevant section. However, some more generic issues raised are considered below.

217 A member of the public (GDA66) commented '*In France, ASN requires the PWRs to be dismantled and internally inspected every 10 years, this takes 3 months off-line. Will a similar routine apply to the UK EPRs?*'. The requirement for inspection and maintenance of the UK EPR is not addressed in detail in GDA. However, future operators will be required to have appropriate arrangements in place to comply with both our environmental permits, and ONR's site licence. These will include appropriate arrangements for Examination, Maintenance, Inspection and Testing (EMIT).

218 The Greater Manchester Socialist Environment Resources Association (SERA) (GDA125) raised a number of issues in response to our consultation. These included comments about the finances of EDF and AREVA in the current economic climate '*may result in reduction of critical funding for safety features and communications in the future*'. SERA commented '*SERA is not satisfied that EDF AREVA have taken account of the changing workforce implications between those who design and build the proposed new design reactors and those in the utility companies who may be commissioned to run them. … there are likely to be complexities where the transfer of knowledge has been hampered by issues of commercial confidentiality. The operating utility companies may have too great a gap in their operating instructions to be able to run the plant safely. This potential for knowledge gaps needs to be covered. There will also be language and interpretation issues for future generations*.' The issue of finance is not considered to be within the scope of GDA. However, we do consider below the development of the intelligent operator for the UK EPR design in regard to the transfer of knowledge about the design between EDF and AREVA and the future operator. We expect any future operator of the UK EPR to be an intelligent customer for its design.

5.6 Expectations for the operator's management system

219 Before a site-specific application for a UK EPR can be made, the potential operator will need to begin establishing its management system, including organisational structure and resources, and there will need to be considerable knowledge transfer about the design. We, therefore, need EDF and AREVA to address, in its GDA submission, the implications of the design for the potential operator's management system, and how it intends to transfer the necessary information and provide ongoing support to the potential operator.

220 Ingleby Barwick Town Council (GDA38) responded that '*support must be given to contractors who will run the reactor, mechanism needed to respond to audits. System needed for spreading information to all involved in design, construction, and initial start up and throughout reactor life. Training programme required*'.'

221 Springfields Site Stakeholder Group (GDA96) commented in regard to our preliminary conclusions on management systems '*in basic agreement with the preliminary conclusions for both designs, assuming that effective interactions continue between the vendors, utilities and Regulators to maintain and improve standards*'.

222 Issues concerning the transfer of knowledge about the design between the vendor and the future operator were examined by the Regulators in GDA and are discussed below. We assessed evidence provided by EDF and AREVA against our expectations for the operators management systems.

223 Reference 1.1 of Table 1 of our GDA guidance document, the process and information document (Environment Agency, 2007) requires EDF and AREVA to set out their expectations of the operator's management system to cover the reactor's operations throughout its lifecycle. With ONR we asked EDF and AREVA to address, in their GDA submission, the implications of the UK EPR design for the potential operator's management system. In particular, how EDF and AREVA intend to transfer the necessary information about the UK EPR design, and the arrangements to provide ongoing support to the potential operator. The EDF and AREVA submission addresses these matters in the PCER at sub-chapter 2.1 'Project Organisation'.

224 The operator is required to establish a design authority, with arrangements in place to make sure that enough information and knowledge about the design is transferred from EDF and AREVA, as the design organisation, to the operator so that it can act as an effective design authority. EDF and AREVA are a unique requesting party in GDA as co-applicants.

225 The PCER (sc2.1s3) sets out the expectations of the post GDA organisation. This is defined according to the plant owner or operator, the architect engineer and suppliers. It is recognised in the PCER submission document that the plant owner (operator) will have safety and environmental responsibilities in relation to plant operation, waste and effluent management.

226 EDF and AREVA set out a number of possible approaches to transferring knowledge and developing an 'intelligent operator' (we use the term to describe the capability of an operator to have a clear understanding and knowledge of the reactor design being supplied), given that, at this stage, the future operating organisation is not known.

227 EDF's approach is to include the co-designer, the architect engineer and the future operator within the same company. This approach will help to transfer knowledge and information.

228 In developing 'intelligent operator' capability, EDF participates in a knowledge transfer programme, which takes account of EDF operating experience feedback. EDF is the world's largest nuclear operator, and currently operates 58 nuclear power plants (CEA Nuclear Power Plants in the World 2008 Edition). The operator will be integrated into the engineering design, operation and procurement processes with specific responsibilities for specifying UK requirements, and the final stage of design reference and safety case.

229 AREVA's approach as the vendor, to help transfer knowledge and provide ongoing support to the potential operator, will depend upon the future owner / operator organisation. AREVA sets out its expectations and how they can be achieved. AREVA will use its knowledge, based on 35 years experience in building nuclear power plants and organising the associated transfer of knowledge to the plant owner and operator, to allow the plant to operate safely and efficiently.

230 AREVA indicated that several utilities were integrated in the EPR basic design phase, participating in technical and project working groups. In addition, studies were carried out under the responsibility of the utilities in areas such as overall operation policy, and availability and maintenance analysis. AREVA also references the European Utility Requirements (EUR) document, specifically the EPR sub-set to illustrate the ongoing utility-vendor interface for the EPR.

231 AREVA recognises that transferring knowledge to operators is important to ensure that the future owner / operator can secure and maintain the safety and environmental performance for the EPR. AREVA organises workshops and seminars with potential utility customers to provide technical information on the EPR design and to exchange information on the technical scope, and knowledge transfer.

232 The knowledge transfer stage includes both handing over technical data and information, and also training programmes. Interfaces with sub-contractors and utilities are detailed in configuration and design change management procedures for each project. AREVA also sets out its training programme information to help develop the knowledge, skills and behaviours needed to safely operate the EPR. The owners' group has arrangements in place to help share feedback experience from operating plants between the utility and the vendor.

233 We consider that EDF and AREVA have demonstrated that they understand the requirement to establish arrangements to maintain design integrity, and to preserve the necessary detailed and specialised knowledge generated over the plant's operational life for the UK EPR. AREVA has arrangements in place to help transfer the necessary knowledge and information, and to fully support the plant owner / operator at all phases of the nuclear new build project, by providing training programmes and transferring data and document and technical information.

234 We conclude that EDF and AREVA have adequately specified:

a) its expectations for any operating utility's management system;

b) how it expects to transfer knowledge and provide continuing support to any operating utility.

235 West Somerset Council and Sedgemoor District Council (GDA154) note '*We have no fundamental observations with regard to the conclusion (in the paragraph above), we consider it important, especially for those in the locality of proposed nuclear power stations, that the scrutiny and maintenance of quality, of management systems employed is a "beginning to end" activity which must extend over many decades'*.

236 Another respondent (GDA123) queried '*What will the final operational management system be based on- will it be the same as used for the GDA process. How will the operating company's culture be conveyed i.e. French and American into British?*'.

237 The scrutiny of management systems is an aspect of permitting by the Environment Agency and licensing by ONR that is carried out at the site-specific permitting/ licensing stage. There will be specific requirements under both ONR's licence and our permit conditions to maintain appropriate management systems. As noted above, we are currently determining applications for environmental permits by NNB GenCo to operate a twin UK EPR at Hinkley Point in Somerset, and one part of our determination is to assess NNB GenCo's proposed management system.

238 NNB GenCo (GDA106) responded to the consultation as prospective owner / operator within the EDF Group of nuclear facilities using the UK EPR design. They confirmed NNB GenCo '*has initiated and will continue to develop management arrangements that are in accord with all regulatory requirements and fit for purpose for a competent nuclear operator. In developing these arrangements, NNB GenCo will be able to take advantage of accumulated experience within the EDF Group of operating 58 nuclear power plants in France and 8 nuclear power stations in the UK.*'

239 Horizon Nuclear Power (GDA127) noted ' *for utilities other than EDF, AREVA alone will be responsible for providing the UK EPR for site-specific projects… We*

acknowledge that the process of knowledge transfer from Areva to Horizon has already started… Horizon is able to draw on the expertise and knowledge of E.ON Kernkraft and RWE Power, who were involved in the EPR basic design phase'.

240 Scottish Power (GDA163) responded on behalf of its parent company Iberdrola. Iberdrola is partnering with GDF Suez, with a view to undertaking new nuclear build in the UK, the consortium is now a joint venture company known as NuGeneration Ltd (NuGen). They noted that a different operator, to the co-applicant in the joint requesting party for GDA, could be involved in operating the EPR in the UK and that there may be a different approach to transfer of knowledge to the operator.

6 Integrated waste strategy

6.1 Conclusions

241 Our conclusions have been updated since our consultation as a result of additional information. Decommissioning is no longer the subject of a GDA Issue, but we have identified a new assessment finding on this subject.

242 **We have concluded that:**

a) **EDF and AREVA have provided a reasonable radioactive waste and spent fuel strategy for all waste streams that a UK EPR will typically produce.**

b) **The radioactive waste and spent fuel strategy is consistent with recent government statements (BERR, 2008a).**

c) **The UK EPR design facilitates decommissioning, and uses BAT to minimise decommissioning waste and the impacts on people and the environment of decommissioning operations.**

243 As part of our assessment, we identified the following assessment findings:

a) The future operator shall, at the detailed design stage, identify any changes to the ‘reference case’ for solid radioactive waste and spent fuel strategy, and provide evidence that the site-specific integrated waste strategy (IWS) achieves the same objectives (UK EPR-AF01).

b) The future operator shall, at the detailed design stage, provide an updated decommissioning strategy and decommissioning plan (UK EPR-AF02).

6.2 Background

244 We expect new nuclear power plant designs to be developed in line with a radioactive waste and spent fuel strategy that seeks to:

a) minimise the production of radioactive waste;

b) manage unavoidable waste and spent fuel to achieve an optimal level of protection for people and the environment.

245 Our radioactive substances regulation environmental principles (REPs) (Environment Agency, 2010c) set out the issues that this type of strategy should take into account. For new nuclear power plant designs, the strategy also needs to be consistent with recent government statements (BERR, 2008a) that:

a) the disposal of intermediate level radioactive waste (ILW) to a future geological repository, from any new nuclear power stations, is unlikely to occur until late this century;

b) any nuclear power stations that might be built in the UK should proceed on the basis that spent fuel will not be reprocessed.

246 A number of consultation responses were received in regard to the integrated waste strategy (IWS) which are discussed in the relevant parts of this chapter. Questions on the IWS were also raised at our 6 July GDA stakeholder seminar and these are also considered in this chapter.

247 We summarise below the information presented in EDF and AREVA's submission on their IWS. We assessed all this information and used the GDA process of ROs and TQs to query and expand information where necessary. The conclusions of our assessment are provided at the end of each sub-section.

248 We note that ONR has an assessment finding on knowledge management. Successful waste management and decommissioning requires accurate information to be available to the operator and the decommissioning team. Therefore, this finding requires the operator to develop the necessary systems to achieve this. We support this assessment finding and this is in line with our REPs.

6.3 EDF and AREVA's integrated waste strategy

249 EDF and AREVA's IWS outlines their current strategy for managing radioactive and non-radioactive waste, including spent fuel arising from the construction, operation and decommissioning of the UK EPR. The strategy is supported by:

a) a BAT assessment in the PCER (Chapter 8);

b) radionuclide specific BAT assessment reports in the EPRB;

c) impact assessments in the PCER (Chapters 11 and 12).

250 EDF and AREVA present a 'reference case' for solid radioactive waste and spent fuel strategy based on the waste and spent fuel management practices and arrangements of the reference plant for the UK EPR at Flamanville 3. In addition, since potential UK EPR operators may wish to adopt alternative spent fuel and waste management arrangements, other possible options to the reference case are presented in a solid radioactive waste strategy report (SRWSR). EDF and AREVA state in the IWS that the SRWSR does not provide respective BAT assessments for the options, but they have a high degree of confidence that such cases can be made by potential UK EPR operators.

251 EDF and AREVA claim in their IWS that there is a management strategy for all waste streams produced by the UK EPR and that their proposals minimise the amount of waste produced by adhering to the waste hierarchy and BAT. They also claim that there are adequate controls to manage unavoidable waste and spent fuel to achieve an optimal level of protection for people and the environment. EDF and AREVA claim that all waste that cannot be reused or recycled is disposable.

252 EDF and AREVA state in their IWS that when considering the options for treatment of individual waste streams, the preferred approach used for the UK EPR design involved considering the balance between gaseous and aqueous discharges, and the generation of solid waste, while favouring a strategy of '*concentrate and contain*'. (The '*concentrate and contain*' option 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 aqueous radioactivity into the environment (DECC, 2009a)). The Institution of Mechanical Engineers (GDA145) responded to our consultation saying that it supports the principle of '*concentrate and contain*' as the preferred process for the radioactive waste strategy. Stop Hinkley (GDA157) provided the following response: '*We applaud the preference for the principle of 'concentrate and contain' not 'dilute and disperse' referred to in paragraph 166. Unfortunately the text does not seem to receive ownership by the Environment Agency, who we believe should approach all radioactive waste issues with this as the primary principle rather than BAT or ALARP*'.

253 We base our regulatory decisions on applying all the environmental principles set out in the 2009 Statutory Guidance (DECC, 2009a), one of which is: '*the preferred use of "concentrate and contain" in the management of radioactive waste over "dilute and disperse" in cases where there would be a definite benefit in reducing environmental pollution, provided that BAT is being applied and worker dose is taken into account*'. We note that it is not practical to capture all gaseous and aqueous waste streams, but we require BAT to minimise the radioactivity content of such discharges.

254 In 2006, the Government's response to recommendations by the Committee on Radioactive Waste Management (CoRWM), established that, in England and Wales, deep geological disposal is the preferred route for the long-term management of radioactive waste that is not suitable for near-surface disposal. It also gave the responsibility for implementing the programme for a deep geological repository to the Nuclear Decommissioning Authority (NDA). To take this into account, ONR, the Environment Agency and the Scottish Environment Protection Agency (SEPA) have developed a series of joint guidance documents on the management of higher activity radioactive waste (available at http://www.hse.gov.uk/nuclear/wastemanage.htm). These specify the production, content, maintenance and review of radioactive waste management cases (RWMCs). The RWMC should demonstrate the long-term safety and environmental performance of the management of higher activity radioactive waste from generation to conditioning into a form that will be suitable for storage and eventual disposal. EDF and AREVA have provided a mapping document that identifies how their existing documentation forms the basis of a RWMC for the UK EPR. This was updated by EDF and AREVA in January 2011 (see Schedule 1 of Annex 1).

255 EDF and AREVA state in their IWS that solid radioactive waste arisings from the management of discharges are optimised. Solid radioactive waste will be disposed of as soon as practicable where an appropriate disposal route is available. The operator will dispose of LLW to the low level waste repository (LLWR) and ILW to the geological disposal facility (GDF) when it is available. In the interim, ILW will be stored on site in a dedicated building(s).

256 EDF and AREVA state in their IWS that their strategy for the management of aqueous radioactive waste for the reference case is based on:

a) minimising the production of effluents at source;

b) optimum use of segregation and effluent treatment systems;

c) optimum use of suitable storage systems for the site.

257 EDF and AREVA state in their IWS that their management strategy to limit radioactive gaseous discharges from the operating activities of the UK EPR is based on the design of the plant and the operational practices to be implemented. They claim that they will use BAT to minimise gaseous discharges at source and similarly in abatement plant, and balance worker doses and costs incurred during treatment in the plant with public doses from discharges. Stop Hinkley (GDA157) provided the following response to our consultation: '*We believe that even with the extra costs of high level protective gear that the industry should take every conceivable measure to incur no doses to the public*'.

258 We note that our statutory guidance concerning the regulation of radioactive discharges into the environment (DECC, 2009a) has the following environment principle; optimisation of protection on the basis that radiological doses and risks to workers and members of the public from a source of exposure should be kept as low as reasonably achievable (the ALARA principle).

259 The IWS is consistent with recent government statements (BERR, 2008a) as EDF and AREVA have made provision in the design for ILW to be stored on site until the GDF is available for its disposal.

260 The IWS takes into account statutory guidance concerning the regulation of radioactive discharges into the environment (DECC, 2009a). In particular, as EDF and AREVA have used the principle of '*concentrate and contain*' in their UK EPR design.

261 Maldon Town Council (GDA51) commented that the waste strategy is '*not up to the specification of Magnox South, for example at Bradwell decommissioning standard*'. We do not expect the IWS to have the same level of detail as that of an existing plant or one that is undergoing decommissioning. However, we do expect the IWS to be reviewed and updated as necessary. We also recognise that the IWS will evolve with time and become more fully optimised as techniques and technologies improve.

262 Maldon Town Council (GDA51) also commented that EDF and AREVA seem to want to dispose of waste as soon as possible. We require that radioactive wastes are safely disposed of, at appropriate times and in appropriate ways and for GDA, we conclude that EDF and AREVA's strategy is reasonable. Government policy (Cm2919) states that: '*In preparing programmes and plans for the management of operational LLW, there should be a presumption by the waste manager towards management solutions which can be implemented early rather than late. Early solutions does not necessarily equate to early disposal. For example, decay storage of wastes pending final disposal is perfectly acceptable provided that the decay storage provides a genuine benefit. The objective should be to put such solutions in place prior to the implementation of those programmes and plans wherever possible. Where this is shown not to be possible, or inappropriate, any interim management of these wastes will need to be conducted in a manner that is acceptable to Regulators, and that takes account of the agreed final disposal route(s) identified from the options' assessments.*' (HMSO, 1995)

263 Maldon Town Council (GDA51) also said that transporting this waste was not mentioned. We do not regulate the safe transport of radioactive material and hence we did not include this in our assessment and consultation.

264 Several respondents were concerned about the availability of a LLWR and a GDF. These responses are considered in chapter 10, and a GDF is also considered in chapter 11 and Annex 8.

265 Greenpeace (GDA151) responded that the consultation should be withdrawn and undertaken only when the waste management proposals become firm plans which could be implemented. We have received credible plans which could be implemented if needed. This will be part of our site-specific assessment. We have concluded that for GDA, the radioactive waste strategy is reasonable for all waste streams that the UK EPR will typically produce and that it is consistent with recent government statements (BERR, 2008a).

266 Studsvik UK Ltd (GDA131) commented that BAT needs to be applied to the waste treatment options as well. As stated above, EDF and AREVA present a '*reference case*' for solid radioactive waste and spent fuel strategy based on the waste and spent fuel management practices and arrangements of the reference plant for the UK EPR at Flamanville 3. In addition, since potential UK EPR operators may wish to adopt alternative spent fuel and waste management arrangements, other possible options to the reference case are presented in the SRWSR. EDF and AREVA state in the IWS that the SRWSR does not provide respective BAT assessments for the options, but they have a high degree of confidence that such cases can be made by potential UK EPR operators. To ensure the plans and

strategies of future operators are optimised, we have included the assessment finding below.

267 At our stakeholder seminar, a question was asked whether any new wastes arise from the design. We have concluded from our assessment that the waste streams that the UK EPR will typically produce are similar to those from existing nuclear power plants.

268 Several respondents, including; individual respondents (GDA25, GDA84), the Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA67),Springfields Site Stakeholder Group (GDA96), Sellafield Ltd (GDA126), Horizon Nuclear Power (GDA127) and the Institution of Mechanical Engineers (GDA145) said that they were satisfied with our conclusions on the IWS. Springfields Site Stakeholder Group (GDA96) said that it assumes that the strategy is consistent with waste hierarchy principles. We confirm that it is.

269 **We have concluded that:**

a) **EDF and AREVA have provided a reasonable radioactive waste strategy for all waste streams that a UK EPR will typically produce.**

b) **The radioactive waste strategy is consistent with recent government statements. (BERR, 2008a)**

270 **The radioactive waste strategy is a 'reference case' based on the waste and spent fuel management practices and arrangements of the reference plant for the UK EPR, Flamanville 3. The reference case is reasonable, however we expect the future operator shall, at the detailed design stage, identify any changes to the 'reference case' for solid radioactive waste and spent fuel strategy, and provide evidence that the site-specific IWS achieves the same objectives (UK EPR-AF01).**

6.4 Spent fuel strategy specifics

271 EDF and AREVA present a 'reference case' for solid radioactive waste and spent fuel strategy based on the waste and spent fuel management practices and arrangements of the reference plant for the UK EPR, Flamanville 3. Other possible options to the reference case for spent fuel strategy are presented in a solid radioactive waste strategy report (SRWSR).

272 Five interim storage solutions are identified in the solid radioactive waste strategy report, SRWSR, including underwater long-term pool storage and four types of dry storage. Wet storage is the usual practice in nuclear power plants and is used for initial cooling, and subsequently may be used for interim storage, before final disposal. Dry interim storage for spent fuel is used in Europe and the USA.

273 Of the five options, one wet pool storage, and two dry storage solutions were identified and assessed in more detail for the UK EPR. EDF and AREVA considered the regulatory requirements for interim storage facilities and in particular Environment Agency requirements in relation to BAT and our radioactive substances environmental principles (REPs).

274 EDF and AREVA considered three spent fuel storage technologies, based on available and proven technologies:

a) wet interim pool storage- fuel assemblies stored in a pool;

b) dry interim cask storage- fuel assemblies stored in metal casks;

c) dry interim storage in purpose designed stores- fuel assemblies stored in vault type storage.

275 The dry interim storage facility uses metallic storage flasks technology; the TN-DUO flask which is designed for both transport and storage. Information is provided on the building layout and safety features in the SRWSR. The storage facility is designed to operate for 100 years. Visual surveillance is carried out as part of a maintenance programme for flasks in the interim storage facility. A permanent check system is implemented which monitors any pressure drop in the interspace between the primary and secondary lid of the TN-DUO flask.

276 The dry storage vault involves placing fuel assemblies into canisters when they are received. The stainless steel canisters contain aluminium partitions to house fuel assemblies and ensure heat dissipation. Details are provided on the building layout and safety features in the SRWSR.

277 These designs allow for retrieval and inspection of the fuel, and for refurbishment. Further information on wet interim storage is provided in chapter 11.

278 Maldon Town Council (GDA51) noted it was satisfied with the strategy for pool storage, but that it was '*not sure on strategy of dry spent fuel*' storage.

279 An individual respondent (GDA66) commented '*the transfer of spent fuel from the pond after 10 years to dry casks is the only acceptable system. The US open air "cemetery" is preferred over the Sizewell B (also in Switzerland and Belgium) solution of a mausoleum'*.

280 We note that storage of spent fuel is regulated by ONR, and these comments have been passed to ONR for consideration. However we do have an interest in storage as it may give rise to secondary arisings, and also affects eventual disposal.

281 Blackwater Against New Nuclear group (BANNG) (GDA113) raised issues around the various proposals for spent fuel management for both designs in GDA suggesting there was a lack of clarity about spent fuel management strategy. They commented that '*there is little specific information on conditioning, storage and transport to a repository… rather a general outline of proposals is offered… BANNG believes that detailed design proposals for the management of spent fuel must be prepared and accepted before authorising the operation of new nuclear power stations'*. We consider that sufficient information for spent fuel management strategy is provided for GDA, and further information is provided in chapter 11.

282 EDF and AREVA produced the RWMC mapping document to demonstrate how they could meet regulatory expectations, and identified the information required to produce the RWMC for spent fuel. The RWMC demonstrates the longer term safety and environmental performance of waste for the planned management from generation to conditioning to a form which will be suitable for storage and eventual disposal. The report identifies the existing documents that form the basis of the RWMC, and maps the RWMC requirements against specific submission document sections. It covers spent fuel management throughout the reactor lifecycle. The report was updated by EDF and AREVA in January 2011.

283 EDF and AREVA's IWS states there is a spent fuel interim store with sufficient capacity to store all spent fuel assemblies generated by the reactor, assuming 60 years operation for the UK EPR, for about 100 years before final disposal. The design of the store is claimed to provide adequate space and handling for safe operation, and monitoring of the condition of the spent fuel. The store is designed to be maintained to last for about 100 years from when spent fuel is first emplaced in the store.

284 Interim storage may be required potentially beyond 100 years to cover the lifetime of reactor operations (including the final emplacement of fuel to interim storage, following an initial cooling period in a pool after reactor operations cease), the time to reduce the heat generation of the fuel. Potential for refurbishment of the store(s) would be considered if required.

285 The time period for spent fuel storage was raised in consultation responses, noting that EDF and AREVA's proposals are for at least 100 years after the spent fuel is first emplaced in the store. West Somerset Council and Sedgemoor District Council (GDA154) and Stop Hinkley (GDA157) refer to a period of 160 years for on-site storage of fuel – 100 years for on-site storage from the National Policy Statement (NPS) and 60 years of operational life for the reactor. The Nuclear NPS, Annex B radioactive waste management, states '*the Government does not expect on-site interim storage to be required for as long as 160 years. Moreover there are some factors which might cause this on-site interim storage period to be significantly shorter, for example it is not necessarily the case that the whole interim storage period for the spent fuel produced by a new nuclear power station will be on-site*'.

286 Stop Hinkley (GDA157) also raised issues for high burn up fuel and length of storage. This is considered in chapter 11.

287 The issue of final disposal of fuel was raised in consultation responses and is discussed in chapter 11.

288 West Somerset Council and Sedgemoor District Council (GDA154) also noted that the '*longevity of spent fuel storage at reactor sites is clearly of great concern to potentially affected localities*'. Further discussion is provided in Annex 8 in regard to concerns raised by local communities.

289 Other comments were made on spent fuel storage and disposal, and are discussed in chapter 11.

290 The Regulators requested further information about long-term storage, including a plan showing when waste management facilities will be developed and constructed, and the research needed to underpin the plan for longer term storage to ensure the spent fuel can be stored, transported and disposed. EDF and AREVA provided additional information in March 2010, and we noted in our consultation that ONR was continuing to review this information in its Step 4 assessment. ONR has now advised us that the spent fuel can be maintained in a suitable condition during on-site storage such that it will remain acceptable for disposal, and further information is provided in chapter 11.

291 We consider the proposals for wet and dry storage to be acceptable.

292 EDF and AREVA take account of Government policy in their IWS (BERR, 2008a) and make the following assumptions:

a) Spent fuel will be declared as waste and will not be reprocessed.

b) Spent fuel will be stored on-site followed by disposal to a geological disposal facility (GDF) at the appropriate time.,.

293 The IWS indicates that the UK EPR design allows for spent fuel to be stored in an on-site fuel store designed to accommodate the lifetime arisings of spent fuel from the nuclear power station. PCERsc6.2s3.4.2 notes one or more options for spent fuel storage, including an on-site interim storage facility and / or construction and operation of an interim spent fuel storage facility shared between several sites.

294 EDF and AREVA provided information on the measures incorporated in the design and the use of fuel materials, and reactor controls in order to retain activity in the fuel.

295 Support for our conclusions on spent fuel management strategies came from the Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA67). They noted *'the conclusions on radioactive waste management and spent fuel management strategies are well founded, particularly noting their consistency with formal UK positions'*. Support for our conclusions was also noted from the Institution of Mechanical Engineers (GDA145). Springfields Site Stakeholder Group (GDA96) indicated their support '*in agreement with the preliminary conclusions*'.

296 Support for our conclusions on spent fuel management was also noted by Sellafield Ltd (GDA126), and Horizon Nuclear Power (GDA127). An individual respondent (GDA84) indicated support in responding to the consultation question on our preliminary findings on waste and spent fuel strategy '*this is fine*'.

297 Suffolk Coastal District Council (GDA165) responded to our consultation to note it had '*confidence in the technical appraisals undertaken by both the Environment Agency and the HSE and supports the overall conclusions of the GDA'*. It also noted that there remain concerns about the longer term potential for the degradation of spent fuel. This is discussed further in chapter 11.

298 NNB Genco (GDA106) responded as a prospective operator '*We welcome the Environment Agency's conclusion that … spent fuel from a fleet of UK EPRs would be disposable in a suitably designed and located UK Geological Disposal Facility (GDF), subject to a satisfactory demonstration that spent fuel can be stored safely for the necessary period of time without significant degradation….Outside of the GDA process, prospective operators including NNB GenCo are already working with the Radioactive Waste Management Directorate (RWMD) to progress key issues, including the duration of interim storage prior to emplacement and the optimisation of the GDF design for both legacy and new build waste.*'

299 The radioactive waste strategy is a 'reference case' based on the waste and spent fuel management practices and arrangements of the reference plant for the UK EPR, Flamanville 3. The reference case is reasonable, however we expect the future operator shall identify any changes to the 'reference case' for solid radioactive waste and spent fuel strategy, and evidence that the site-specific IWS achieves the same objectives at the detailed design stage (UK EPR-AF01).

300 **We have concluded that:**

a) **EDF and AREVA have provided a reasonable strategy for spent fuel that will be produced by the UK EPR.**

b) **The spent fuel strategy is consistent with recent government statements (BERR, 2008a), and our REPs (Environment Agency, 2010c).**

6.5 Decommissioning specifics

301 In line with Government policy (DTI, 2004), we expect:

a) the radioactive waste and spent fuel strategy to address decommissioning;

b) the design to use the best available techniques to:

   i) facilitate decommissioning;

   ii) minimise decommissioning waste;

   iii) minimise the impacts on people and the environment of decommissioning operations and the management of decommissioning waste.

302 EDF and AREVA's UK EPR decommissioning strategy is described in Chapter 5 of the PCER. This chapter includes the measures adopted at the design stage to facilitate decommissioning. Further information on decommissioning, including dismantling methodologies considered for the UK EPR and decontamination techniques, are in the solid radioactive waste strategy report (SRWSR).

303 The SRWSR states that the UK EPR design will enable decommissioning to be performed to minimise radiation doses to the workers and minimise radioactive waste generation. The SRWSR discusses the following features that have been incorporated into the design:

a) choice of materials of construction to minimise activation;

b) optimisation of neutron shielding;

c) optimisation of access routes to nuclear areas;

d) reactor systems design;

e) ease of removal of major process components;

f) submerged disassembly of reactor pressure vessel;

g) modular thermal insulation;

h) fuel cladding integrity;

i) design for decontamination;

j) prevention of contamination spread;

k) minimisation of hazardous materials.

304 We noted in our consultation document, that ONR were requesting further information from EDF and AREVA on decommissioning for consideration in its Step 4 assessment. We also expected further detailed evidence to be provided in GDA on decommissioning, as this would assist any future operator in providing a Decommissioning and Waste Management Plan for agreement by the Department of Energy and Climate Change (DECC) Secretary of State (see BERR 2008b). EDF and AREVA provided this additional information in November 2010 (see Schedule 1 of Annex 1). We have assessed this additional information and have concluded that the design does consider the whole life-cycle of the UK EPR, including decommissioning. The UK EPR design facilitates decommissioning, and uses BAT to minimise decommissioning waste and the impacts on people and the environment of decommissioning operations. We are therefore satisfied that decommissioning is no longer a GDA Issue. However, more detailed information will be required at the detailed design stage. We have therefore captured this as an assessment finding (UK EPR-AF02).

305 We note that ONR has an assessment finding to review the construction activities to identify any actions that could be taken during construction that would be beneficial to the decommissioning process. We support this assessment finding.

306 EDF and AREVA also provided us with additional information in December 2010 on decontamination (see Schedule 1 of Annex 1) which shows their decontamination strategy and the decontamination systems and techniques for deployment during operations, maintenance and decommissioning.

307 One of the questions raised at the stakeholder seminar was whether the GDA process would capture decommissioning. We have addressed decommissioning and as mentioned above, since our consultation document was published, we have received further information on decommissioning from EDF and AREVA (see Schedule 1 of Annex 1).

308 Another question raised at the stakeholder seminar, was whether decommissioning was just a UK issue or has it been looked at in other countries. We have spoken to Regulators in other countries, for example STUK, ASN and NRC and they are also looking at decommissioning. For example, US NRC Regulatory Guide 4.21 states: '*Applicants for standard design certifications, standard design approvals, and manufacturing licenses …… shall describe in the application how facility design will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste*.'
(See http://nrc-stp.ornl.gov/special/reg_guide4-21.pdf)

309 A further question raised at the stakeholder seminar, was: '*Is it fair to push the decommissioning issue onto regulatory parties when UK government is actually responsible for creating circumstances to all clear decommissioning strategy*.' We expect new plants to be designed taking account of the need to facilitate decommissioning. In accordance to our REP DEDP2, initial decommissioning plans should be prepared during the design and construction of new facilities.

310 We were also asked at our stakeholder seminar, to what extent has previous experience in radioactive waste management and decommissioning been taken into account. For GDA, we are only reviewing the information submitted by the RPs on the reactor designs, although EDF and AREVA have included learning from experience principles.

311 We were asked at our stakeholder seminar whether the decommissioning assessment will look at the reuse of materials. In accordance with our REP DEDP1 on decommissioning strategy, the strategy should incorporate the use of the best available techniques to minimise the generation of radioactive and non-radioactive wastes, particularly by re-using equipment, facilities and buildings, and by re-using or recycling materials. Therefore, we have looked at this in our assessment and concluded that EDF and AREVA have considered the reuse of materials.

312 Suffolk Coastal District Council (GDA165) responded to our consultation saying that it has confidence in the technical appraisals undertaken by both the Environment Agency and the Health and Safety Executive and it supports the overall conclusions of the GDA. However, it also said that there remain concerns about the lack of detailed evidence in respect of decommissioning and its likely impacts. As mentioned above, since our consultation, we have received additional information from EDF and AREVA (see Schedule 1 of Annex 1) that we have reviewed and considered in making our decision.

313 Stop Hinkley (GDA157) provided the following response: '*We note the EA's intention in paragraph 195 to obtain more detailed information from EDF and AREVA on how exactly the EPR can be decommissioned safely. The outcome of the Magnoxes not being designed with decommissioning in mind is a long and fraught process for engineers, as discussed in the BNFL Magnox decommissioning dialogues, attended by Stop Hinkley*'.

314 Horizon Nuclear Power (GDA127) provided the following response: '*We appreciate that the EA's conclusions on decommissioning in the consultation document are focussed on the design of the EPR and it is right and proper that AREVA and EDF should respond to this aspect since this is under their full control. However, we are also aware that the EA has requested information from AREVA and EDF about decommissioning that goes beyond the reactor design and impinges on the operational issues associated with decommissioning. We believe it is important to draw the distinction between generic, site-specific and operational issues and that each of these should be considered at the appropriate stage of the relevant licensing and permitting processes during the lifetime of the project. We note that*

decommissioning of the AP1000 has been identified as a potential GDA Issue. E.ON KernKraft and RWE Power (the subsidiary companies of our parent companies E.ON AG and RWE AG respectively) are currently undertaking several large-scale reactor decommissioning projects in Germany. Their experience shows that decommissioning of a PWR is actually more of a management than a technical challenge. Providing that good housekeeping is maintained during operations, experience shows that it will be possible to undertake decommissioning in an efficient and effective manner. We would hope that the EA's continuing work will conclude that decommissioning is not a GDA Issue. All of the technologies required to perform decommissioning of modern PWRs in a safe, reliable and efficient manner are available today and are being deployed in active decommissioning projects. Good design of modern PWRs will make decommissioning easier and it is appropriate that reactor vendors expend considerable resources to ensure that reactors built to their designs can be efficiently and effectively decommissioned. Experience in Germany has demonstrated that the key to a successful decommissioning project is for the operator to plan carefully the logistics of how the available technologies are deployed in practice. Whilst the detailed design of the PWR itself can aid decommissioning, it is not necessarily the primary contributor to a successful project.' We asked for information in accordance with our REPs on decommissioning. We agree that the operator will have a key role to play throughout the operation of the reactor and during decommissioning to minimise the waste produced from decommissioning. Hence, the operator shall update the decommissioning strategy and plan throughout the lifecycle of the nuclear power plant.

315 The Institution of Mechanical Engineers (GDA145) responded to our consultation with the following two comments:

a) *'Whilst the Institution agrees that a high level Decommissioning Strategy is required at this stage and design features to aid decommissioning must be considered and implemented, it is unreasonable to expect too much detail at this stage. As the operating life of the station will be 60 years much experience will be gained and new techniques will emerge during this period.'*

b) *'The Institution acknowledges that the SRWSR states that the UK EPR design will enable decommissioning to be performed to minimise radiation doses to the workers and minimise radioactive waste generation. The SRWSR also discusses the several features that have been incorporated into the design to aid decommissioning. We await further clarifications as required by the EA during step 4 of the GDA and during the site-specific submission to the Regulators.'*

316 The Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA67) noted that our reservation (in our consultation document) on decommissioning the UK EPR is understandable. It commented that uncertainty around the decommissioning strategy also presents an issue which is likely to undermine arguments to secure public acceptability.

317 We asked for additional information from EDF and AREVA on decommissioning (which, as mentioned above, they provided after the consultation document was issued) but not detailed plans in accordance with our REPs on decommissioning and our guidance on GDA (Environment Agency, 2007). We have assessed this additional information and we are satisfied that the UK EPR can be decommissioned in an environmentally acceptable manner. We have concluded that decommissioning is no longer a GDA Issue.

318 **We conclude that the UK EPR design facilitates decommissioning, and uses BAT to minimise decommissioning waste and the impacts on people and the environment of decommissioning operations. However, the future operator shall, at the detailed design stage, provide an updated decommissioning strategy and decommissioning plan (UK EPR-AF02).**

7 Best available techniques to minimise production of radioactive waste

7.1 Conclusions

319 Our conclusions remain unchanged since our consultation.

320 **We conclude that:**

a) **overall the UK EPR utilises the best available techniques (BAT) to prevent and minimise production of gaseous and aqueous radioactive waste:**

   i) **during routine operations and maintenance;**

   ii) **from anticipated operational events.**

b) **The UK EPR uses BAT to contain liquids and prevent contamination of groundwater in normal operation. The techniques used should also minimise contamination under fault conditions.**

321 As part of our assessment we identified the following assessment findings:

a) Future operators shall keep the removal of secondary neutron sources (to further minimise creation of tritium) under review. EDF and AREVA shall provide future operators with relevant EPR operational information when available to facilitate their reviews of BAT. (UK EPR-AF03)

b) Future operators shall, during the detailed design phase for each new build project, review BAT on minimising the production of activated corrosion products for the following matters, where possible improvements were identified in the PCER (UK EPR-AF04):

   i) corrosion resistance of steam generator tubes;

   ii) electro-polishing of steam generator channel heads;

   iii) specification of lower cobalt content reactor system construction materials;

   iv) further reducing use of stellites in reactor components, in particular the coolant pump.

   Where appropriate, any improvements considered BAT should be incorporated into the new build.

c) Future operators shall, before the commissioning phase, provide their proposals for how they intend to implement zinc injection. The proposals shall be supported by an assessment of the impact of zinc injection on waste and crud composition. (UK EPR-AF05)

d) Future operators shall, before the construction phase, provide the site-specific design of the conventional and nuclear island liquid effluent discharge tank systems. The design shall be justified by a BAT assessment for sizes of tanks and their leak-tight construction. (UK EPR-AF06)

7.2 Background

322 In minimising and managing radioactive waste, we require that best available techniques (BAT) are applied so that new nuclear power station designs are capable of meeting high environmental standards (DECC, 2009a). BAT replaces, and is expected to provide the same level of environmental protection as, the previously used concepts of best practicable environmental option (BPEO) and best practicable means (BPM).

323 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. This process is not restricted to radioactive substances and their resulting doses, but also takes into consideration:

a) safety considerations (for example, protecting workers) and security;

b) wider environmental considerations (for example, using energy and other resources, generating and disposing of conventional waste);

c) social and economic considerations.

Our optimisation methodology is fully described in our guidance '*RSR: Principles of optimisation in the management and disposal of radioactive waste*' (Environment Agency, 2010f). Our approach ensures that the cost of applying techniques is not excessive in relation to the environmental protection they provide.

324 BAT needs to be used throughout a design and over many aspects. We have assessed BAT starting at the source of radioactivity (the reactor), the way in which radioactivity is processed into gaseous, aqueous and solid waste streams and how each of those streams is reduced and disposed of.

325 We will set disposal limits based on the use of BAT. The limits will be set at the minimum levels to permit normal operation and will include contingencies to allow for maintenance and relevant operational fluctuations, trends and events that are expected to occur over the likely lifetime of the plant. (Statutory Guidance (DECC, 2009a) and our REPS (Environment Agency, 2010c) RSMDP12)

326 We received twelve responses on the use of BAT to minimise the production of radioactive waste. Six of those responses generally supported our conclusion, others sought clarification of some issues. One respondent (GDA5) did not agree with our conclusion but did not provide reasons why.

327 Several respondents, in particular GDA126, queried the term BAT and implications on costs, for example BATNEEC (Best available techniques not entailing excessive cost) has been used in the past. As we noted above we have now standardised on the term BAT and this replaces BPM and BPEO and includes an '*economic feasibility*' element. BAT also recognises relevant good practice and is expected to deliver the equivalent level of environmental protection as achieved by the use of BPM and BPEO. Our guidance *'RSR: Principles of optimisation in the management and disposal of radioactive waste*' provides a full explanation of BAT. (Environment Agency, 2010f)

328 A query from our stakeholder seminar was whether any '*BAT were new*' or were all '*tried and tested*'. The UK EPR uses techniques that have been used in other reactors or have been developed from existing techniques.

329 Another query from our stakeholder seminar was where information on all radionuclides generated by the UK EPR can be found. We have provided information on the most significant radionuclides in terms of discharge quantity and

impact later in this chapter. A full list of information is provided by EDF and AREVA in Table 2 of their '*GDA UK EPR – BAT Demonstration*' document.

330 One individual respondent (GDA38) thought we had provided insufficient detail on BAT, in particular with regard to cobalt-60 reduction. Our consultation document aimed to summarise the more detailed information provided by EDF and AREVA in their submission and supporting documents (in particular the '*GDA UK EPR – BAT Demonstration*'), all of which are available on their website. We have stated that BAT is used to minimise production of cobalt-60 at this time, however further techniques may become available to further reduce its production, hence the assessment finding UK EPR-AF04 given above.

331 One individual respondent (GDA38) asked that BAT be reviewed regularly to see if any improvements become available. We confirm that we keep BAT under consideration and review permits regularly to see if improvements are needed to reflect developments and improvements, for example in plant, techniques or operator practice. Our permits include conditions requiring the use of BAT and BAT requires that operators continually assess whether more can be done to reduce discharges.

7.3 Sources of radioactivity

332 This section describes the sources of radioactive materials in the UK EPR that will eventually become waste, and the techniques used to minimise the amount produced. We expect new nuclear power plants to be designed to use BAT to prevent radioactive waste being produced unnecessarily. Where waste is produced, we expect BAT to be used to minimise the amount generated. (Statutory Guidance (DECC, 2009a) and our REPS (Environment Agency, 2010c) RSMDP3)

333 EDF and AREVA state that the origins of radioactive materials within the UK EPR are mainly (PCERsc6.1):

a) activation of chemical species in the primary reactor coolant (the coolant is essentially water with low levels of some chemicals added);

b) corrosion products from the metal components of the reactor system present in the reactor coolant and activated as they pass through the core of the reactor;

c) fission products formed in the fuel. These may leak into the primary coolant through any defects in the fuel cladding.

334 EDF and AREVA provide information in the PCER on the following radionuclides or groups of radionuclides:

a) tritium;

b) carbon-14;

c) noble gases;

d) iodine radionuclides;

e) other radionuclides that can be produced by activation of non-radioactive materials or by fission in fuel. EDF and AREVA group these together as their discharges tend to be minimised by the same techniques (for example, filtration or ion exchange) and they are usually measured as a group using a gross activity method. The most important of these, in terms of impact on dose, are:

   i) cobalt-60

   ii) caesium-134 and caesium-137

iii) strontium-89 and strontium-90

f) a number of other activated corrosion products can also be produced in less significant amounts. These radionuclides include manganese-54, iron-59, chromium-51, nickel-63, silver-110m, antimony-122, antimony-124 and antimony-125.

335 We assessed information provided in the PCER and particularly the EPRB Table 2 and concluded that EDF and AREVA had identified those radionuclides which either:

a) contribute significantly to the amount of activity (Becquerel – Bq) in waste disposals;

b) contribute significantly to potential doses to members of the public;

c) indicate plant performance, for example where the levels of a radionuclide might increase in the event of a deviation from normal plant operation.

336 We summarise below the information presented in the PCER and EPRB on the sources of specific radionuclides and their minimisation. We assessed all this information and used the GDA process of ROs and TQs to query and expand information where necessary. The conclusions of our assessments are provided at the end of each sub-section.

7.3.1 Tritium

337 Tritium contributes significantly to activity in waste disposals and is produced by three main mechanisms and initially contained within the reactor coolant (see PCERsc6.2s1.2.1, PCERsc6.3s6.2.1 and EPRBs3.3s2):

a) activation of boron-10 (present within boric acid) in the reactor coolant. Boron (in particular the isotope boron-10 making up 20 per cent of natural boron) is used to control the reactivity of the reactor. The UK EPR uses boric acid with an enriched boron-10 content, boron enrichment will depend on the fuel management regime used by each operator, this could be at 37 per cent for the first conditioning operation. EDF and AREVA claim that the quantity of boron needed in the reactor coolant has been reduced in the UK EPR by using a burnable poison – gadolinium oxide – within some of the fuel. They claim this has reduced the production of tritium by the UK EPR from this source compared to predecessor reactors despite an increase in power, see paragraph on production below;

b) activation of the lithium-6 content of the lithium hydroxide used for chemical pH control of the reactor coolant to offset the corrosive effect of boric acid. The amount of boric acid needed has been reduced by the use of a burnable poison – see above – and also by using boric acid with an enriched boron-10 (the important neutron absorber) content. This reduces the quantity of lithium hydroxide needed. The UK EPR will also use lithium hydroxide depleted in lithium-6 (containing less than 0.1% lithium-6 while natural lithium hydroxide contains about 7.5 % lithium-6) to reduce tritium production. EDF and AREVA state that if natural lithium were used, tritium production would be 1-2 TBq day^{-1}. However their total tritium “expected performance” disposals (considering the contribution of all tritium sources) equate to less than 0.16 TBq day^{-1};

c) activation of beryllium (initially to lithium-6 then to tritium) in the secondary neutron sources. These antimony/beryllium sources are used to demonstrate the function of neutron measurement equipment, an essential safety feature for plant start-up, and are cased in stainless steel that is permeable to tritium. The

PCER states that production from this source is 9 TBq y^{-1}. The PCER discusses options to remove these sources or to use an impermeable zirconium-based alloy for the cladding, but information from an operational EPR is needed before removal can be assessed. A change in cladding is not considered further as this would be a departure from a proven design and require more frequent change of sources, which may increase occupational radiation exposure and generate more solid waste.

338 The production of tritium (excluding the contribution from the secondary neutron sources) is directly related to power output of the reactor. EDF and AREVA claim that the above measures mean that the UK EPR will release only 4 per cent more tritium than the predecessor 1300 MWe reactor, while its power output is some 25 per cent greater. The predicted production rate is 52 TBq y^{-1}. The majority of tritium produced will be in the form of tritiated water.

339 A respondent, '*Stop Hinkley*' (GDA157), had concerns on the use of a burnable poison. The term poison used for nuclear reactors means that a material, gadolinium oxide in this case, absorbs neutrons reducing or '*poisoning*' the rate of nuclear reaction. This is normally undesirable but introducing some poison in a new fuel load reduces its initial reactivity and reduces the need for high levels of boron to control reactivity in the early part of a power cycle. The gadolinium oxide is consumed or '*burned'* as the power cycle continues so that it has little effect towards the end of a cycle when fuel reactivity is lower. The gadolinium oxide is completely contained within fuel pins and should not be discharged to the environment to cause any health impact. The respondent also said we appeared to discard the issue of secondary neutron sources. We have an assessment finding on this issue to consider removing if and when operational experience indicates this is possible. If it is not possible then our periodic reviews of BAT will pick up the issue of a change of cladding.

340 There are some other sources of tritium:

a) activation of deuterium in the reactor coolant (deuterium is naturally present in water at 0.015 per cent);

b) ternary fission products, normally contained within the fuel cladding;

c) activation of helium pressurising the fuel pins, normally contained within the fuel cladding.

341 More information on these sources is presented in the PCERsc6.3s6.2.1.2. We do not consider these sources are significant as regards discharges. We have not specifically assessed BAT for these sources, but activation of deuterium is unavoidable and fuel cladding integrity is assessed below under noble gases.

342 **Our assessment concluded that EDF and AREVA have demonstrated that BAT is used to minimise the production of tritium in the UK EPR at this time. For the secondary sources:**

a) **we accept that a cladding change should not be pursued at this time;**

b) **we expect EDF and AREVA to assess removing these sources and provide information to future operators when operational experience is available. (assessment finding UK EPR-AF03)**

7.3.2 Carbon-14

343 Carbon-14 contributes significantly to both activity disposals and potential dose and is produced mainly by two mechanisms within the reactor coolant (PCERsc6.3s6.3.1, PCERsc6.3sc7.3.1 and EPRBs3.2):

a) activation of oxygen-17, a naturally occurring stable isotope of oxygen as part of the water molecules making up the reactor coolant. The annual production of carbon-14 from oxygen-17 is calculated as 401 GBq. There is no practicable way to avoid this formation route;

b) activation of nitrogen-14. Nitrogen is used as a cover gas in the system that treats reactor coolant, a certain portion will dissolve in the coolant. The annual production of carbon-14 from nitrogen-14 depends on the dissolved concentration of nitrogen, calculations presented by EDF and AREVA predict 43 GBq at 10 ppm (expected) to 219 GBq at 52 ppm (extreme maximum). EDF and AREVA claim using nitrogen as a cover gas (as used in the predecessor KONVOI design)instead of hydrogen is a safety feature as it reduces risk of hydrogen / air combustion. This offsets the possible 10 – 50 per cent increase in carbon-14 production.

344 EDF and AREVA use 440 GBq y^{-1} as their base value for production of carbon-14. We accept that there are no techniques that can be used to minimise production of carbon-14 from oxygen-17. Management of operational dissolved nitrogen levels is critical to minimise production of carbon-14 from nitrogen-14, this will be reflected in our disposal limits or notification levels, as appropriate.

345 Other minor mechanisms contribute to carbon-14 discharge:

a) a trace of dissolved carbon can be present in the coolant – this can be activated to carbon-14 (PCER6.3s6.3.1.1);

b) nitrogen impurities and oxygen within the fuel can be activated to carbon-14 but the carbon-14 will normally be contained within the fuel cladding (EPRBs3.2);

c) the ‘aeroball’ system used to measure neutron flux within the reactor is driven by nitrogen, the nitrogen can be activated to carbon-14 but production estimates give a maximum of 1.5 GBq y^{-1} (PCERsc6.3s7.3.1.1);

d) the air within the reactor containment contains oxygen and nitrogen that can be activated to carbon-14, the maximum production is estimated as 1 GBq y^{-1} (PCERsc6.3s7.3.1.2).

We do not consider it necessary or proportionate to assess BAT for these sources as they represent less than 1 per cent of the total carbon-14 discharge.

346 **Our assessment concluded that BAT is used in the design of the UK EPR to minimise production of carbon-14 provided that dissolved nitrogen concentrations are minimised by operational controls.**

7.3.3 Noble gases

347 Noble gases are a range of xenon and krypton radionuclides, in particular xenon-133, xenon-135 and krypton-85, these are fission products and are produced by the burn-up of the uranium in the fuel. They are normally contained within the fuel cladding. If there are any fuel defects these gases can pass into the primary reactor coolant. The presence of noble gases in discharges is an indicator of fuel defects. If fuel defects become significant then noble gases will contribute significantly to activity in gaseous waste disposals. (EPRBs3.5)

348 Traces of uranium contamination can occur on the outside of new fuel assemblies (known as '*tramp uranium*') and its fission can also contribute to the presence of noble gas radionuclides in the coolant. EDF and AREVA claim fuel is '*manufactured to stringent specifications and is subject to rigorous inspection*'. They claim that '*tramp uranium*' cannot be totally avoided, but is only present in trace amounts. (EPRBs3.5ss3)

349 In normal operation, a portion of the coolant is passed through the chemical and volume control system (CVCS). If removal of dissolved noble gases from the coolant is required, the CVCS sends the coolant through a degasification system where gases are removed and sent to the gaseous waste processing system (GWPS). Following treatment, the GWPS vents gaseous waste to the main stack. The level of noble gases at the main stack is a reflection of the failure of fuel cladding. (PCERsc6.3s7.4.2.1)

350 EDF and AREVA claim that the amount of fission products reaching the coolant through fuel defects can be minimised at source by '*high standards of fuel design and fabrication*'. For example, there is '*clear separation between the 'controlled' areas where pellets are manufactured and introduced in the cladding tubes which are decontaminated before sealing, and the 'non-controlled' areas in which only sealed rods are handled. The surface contamination level is then checked for each fuel assembly'.* They claim there will only be a small number of pins with minute defects (the 'failed fuel fraction').

351 They claim that AREVA's AFA 3GLE fuel assemblies have '*exhibited consistently high operational reliability with an average annual fuel failure rate of approximately* 10^{-5}' and that this rate is '*less than half of the failure rate at the end of the 1980s*'. The failure rate is the ratio of number of failed fuel pins discharged divided by the number of fuel pins in reactors that have been refuelled during the considered year, (10^{-5} means 10 in a million or one pin in every one hundred thousand). (EPRBs3.5ss1.1 and PCERsc6.1s6.1.2)

352 EDF and AREVA state that the most common causes of fuel failures in operation are grid-to-rod fretting, corrosion and crud, debris, pellet cladding interaction and manufacturing upsets. They participate and contribute in the EPRI (Electrical Power Research Institute – an independent USA organisation) Fuel Reliability Action Plan. The UK EPR design minimises such failures by: (EPRBs3.5ss1.1)

a) Optimising the design of spacers in the assembly grid;

b) minimising initial surface contamination of fuel by best practice in manufacture;

c) minimising crud formation by control of primary circuit chemistry;

d) defining appropriate criteria for fuel design to prevent cladding failure;

e) incorporating an efficient anti-debris device in the fuel assemblies.

353 EDF and AREVA say that any leaking fuel pins identified during refuelling will not be reused. (EPRBs3.5ss3)

354 There are no techniques to prevent the production of xenon and krypton radionuclides within the fuel pins as they are fission products; their production is related to power output. The main factor in minimising discharges of noble gases is the reliability of fuel.

355 The Institution of Mechanical Engineers (GDA145) supported our identification of fuel reliability as a key factor in minimising the production of radioactive waste. They also say that the term crud is inappropriate in reference to fuel pin deposits, they prefer '*corrosion products and other deposits*'. We agree their definition is more accurate but 'crud' is commonly used and is simpler.

356 **Our assessment concluded that the average fuel failure rate quoted by EDF and AREVA is indicative of use of BAT to minimise the release of noble gases from the fuel in the UK EPR. Fuel integrity will be reflected in the disposal limits and notification levels we set for noble gases. Our conclusion is based on the use of AREVA AFA 3GLE fuel assemblies in the UK EPR.**

357 **Argon-41** can be formed by activation of the natural argon content of air within the reactor containment building. It can be collected by ventilation systems and discharged through the main stack. (PCERsc6.3s7.4.2.1)

358 A small amount of argon-41 may also be produced from the argon in air dissolved in the reactor coolant, this is removed and sent to the GWPS with other dissolved gases. (PCERsc6.1s2.4)

359 PCERsc6.3s7.4.2.1 indicates that argon-41 will form 2.9 per cent of the 'expected performance' of total noble gas discharges (23.2 GBq y^{-1} argon-41). The discharge of argon-41 should not increase when discharges of noble gases increase in the event of any fuel defects. However, EDF and AREVA chose to use a discharge value of 2.9 per cent of the 'maximum' for noble gases (653 GBq argon-41) to predict a pessimistic impact for argon-41. The radiological impact from the annual disposal of 653 GBq of argon-41 to air is stated as a dose to adults of 0.014 µSv y^{-1}, to children of 0.0083 µSv y^{-1} and infants of 0.0065 µSv y^{-1} – from PCERsc11.1 Annex 3 Tables B, C and D.

360 The half-life of argon-41 is under two hours and the UK EPR discharge has little environmental impact, 0.0005 µSv y^{-1} to an adult at the 'expected performance' discharge. Argon-41 discharges from PWRs are less than 1 per cent of those from the UK Advanced Gas-cooled Reactors (AGRs) and less than 0.1 per cent of those from Magnox reactors.

361 **We concluded that it is not proportionate to assess BAT in detail for argon-41 discharge but it will be monitored and included within the noble gases total discharge at the main stack**.

7.3.4 Iodine radionuclides

362 Iodine radionuclides, in particular iodine-131 and iodine-133, are produced by fission in the uranium in the fuel or in 'tramp uranium' – as described in the noble gases section above. However, iodine radionuclides tend to remain in the liquid phase in the chemical and volume control system (CVCS) as they are readily soluble. Residual gaseous iodine radionuclides will pass through the gaseous waste processing system to the main stack. The presence of iodine radionuclides in gaseous discharges is another indicator of fuel defects. The UK EPR design also allows for any trace leakage from systems containing primary coolant, the ventilation over such systems can be sent to 'iodine traps' if iodine radionuclides are detected (automatic systems). (PCERsc6.2s1.2.1)

363 We accept that there are no techniques to prevent the production of iodine radionuclides within the fuel pins. The fuel cladding should prevent leakage into the reactor coolant. The integrity of the cladding is discussed above under noble gases, and will be reflected in the disposal limits and notification levels we set.

364 **Our assessment concluded that BAT is used to minimise the release of iodine radionuclides from the fuel in the UK EPR.**

7.3.5 Other radionuclides

365 **Activated corrosion products** – the components of the reactor system are made of various metals and alloys and are in contact with the reactor coolant. The coolant contains chemicals such as boric acid. The coolant can cause erosion and corrosion of the surfaces it contacts and this gives both soluble and insoluble (particles) corrosion products. Radionuclides can be produced by activation of these corrosion products as they pass through the reactor core within the coolant. Activation products can also be formed in structural reactor components, most of the radioactivity produced will remain within the components (a matter for decommissioning) but some can be released by corrosion and erosion. PCERsc6.1s2.6 lists the most significant radionuclides produced (see also PCERsc6.2s1.1.1, PCERsc8.2s3.3.1 and EPRBs3.4). Activated corrosion products, in particular cobalt-60, contribute significantly to potential doses to members of the public from aqueous discharges. The increase in their levels in discharges can indicate poor performance of abatement equipment such as filters or demineralisers.

366 **Manganese-54** from the activation of the iron-54 content of all metallic materials used in the reactor system, no minimisation, apart from corrosion control, is practicable.

367 **Cobalt-58** from the activation of nickel-58, a major constituent of nickel based alloys (for example, the 690 alloy used in the steam generator tubes). EDF and AREVA say that:

a) constant improvements are being made to the corrosion resistance of steam generator (SG) tubes (PCERsc8.2s3.3.1.1.3);

b) they are evaluating electro-polishing of SG channel heads to reduce erosion and corrosion potential (PCERsc8.2s3.3.1.1.5).

The above options would reduce nickel-58 corrosion products entering the coolant. We will require an updated BAT assessment against these options at, or before, the site-specific permitting stage.

368 **Iron-59** from the activation of the iron-58 content of all metallic materials used in the reactor system, no minimisation, apart from corrosion control, is practicable.

369 **Cobalt-60** from the activation of cobalt-59, a major constituent of steels and, in particular, ‘hard’ high cobalt alloys, for example, stellites used in valve seats. The design of the UK EPR incorporates measures to minimise the amount of cobalt in contact with the reactor coolant in the UK EPR (PCERsc8.2s3.3.1.1.1 and EPRBs3.4):

a) by excluding stellites from valves used in the reactor coolant systems. This is estimated to reduce the total dose predicted for the UK EPR by 8 per cent;

b) by reducing the use of stellites in other reactor components. But their programme of improvements is not complete, for example, EDF and AREVA say that: ‘*stellite parts of reactor coolant pumps to be assessed*’. (PCERsc8.2s3.3.1.1.1);

c) EDF and AREVA say they are making ‘*constant improvements*’ to the specification of lower cobalt contents of stainless steels, welding materials and steam generator tubing used in the construction of the UK EPR. (EPRBs3.4ss3.1.2, PCERsc8.2s3.3.1.1.2)

370 We will require an update to the BAT case to show that cobalt content in the UK EPR has been minimised for each new build project. This is addressed by assessment finding UK EPR-AF04.

371 **Chromium-51** from activation of chromium-50, an essential part of stainless steels, no minimisation, apart from corrosion control, is practicable.

372 **Nickel-63** from activation of nickel-62 present in structural materials, in particular alloy 690, no minimisation, apart from corrosion control, is practicable.

373 **Silver-110m** from activation of silver-109 contained in control rods and helicoflex seals. EDF and AREVA state that the UK EPR will:

a) reduce the use of helicoflex seals in favour of graphite seals; but

b) control rods cannot be modified.

374 **Antimony-122 and antimony-124** from the activation of other stable antimony isotopes used as a base for alloys used in some seals and pump bearings. EDF and AREVA state that the UK EPR will reduce the use of bearings containing antimony.

375 **Antimony-125** from the activation of antimony-124 produced as described above. This will be reduced as the production of antimony-124 is reduced.

376 **Corrosion control** – The reduction of corrosion is important to reduce the level of corrosion products. EDF and AREVA state that the UK EPR will:

a) use a programme to produce an oxide layer on reactor circuit components before beginning power operation. This layer reduces the potential for corrosion products to form (PCERsc8.2s3.3.1.1.4);

b) apply a reactor chemistry regime to minimise formation of corrosion products (PCERsc8.2s3.3.1.2);

c) use preventative zinc injection (PCERsc8.2s3.3.1.2.1.2).

377 EDF and AREVA provided additional information on using zinc injection to control corrosion after our consultation. A summary of this information is in the latest revision of the PCER – PCERsc8.2s3.3.1.2.1.2. We assessed this information and reviewed HSE's more detailed assessment on this topic (HSE assessment report EPR – AR 11/024) and concluded that zinc injection has benefits in reduction of discharges. This conclusion is subject to the use of depleted zinc acetate (zinc acetate with less than 1 % zinc-64). However, there is some uncertainty regarding the effect of zinc injection on the composition of some wastes and crud which could affect their disposability. We therefore have identified an assessment finding:

a) Future operators shall, before the commissioning phase, provide their proposals for how they intend to implement zinc injection. The proposals shall be supported by an assessment of the impact of zinc injection on waste and crud composition. (UK EPR-AF05)

378 **Nitrogen-16 and nitrogen-17** are produced by activation of oxygen-16 and oxygen-17 in the reactor coolant. There is no practicable way to reduce them forming. However, their short half-lives, 7.3 and 4.2 seconds, mean that discharges to the environment will be insignificant. We do not consider them further in our assessment. (PCERsc6.1s2.1, 2.2)

379 **Caesium-134, caesium-136, caesium-137 and caesium-138** are fission products normally contained within the fuel cladding. If there are any fuel defects, caesium radionuclides can pass into the primary reactor coolant. We accept that caesium radionuclides production cannot be minimised at source but should be contained. We have commented on the integrity of the cladding above under 'noble gases'. Caesium radionuclides are highly soluble and, if released from the fuel, will be treated in the liquid waste processing system (LWPS). Detecting caesium radionuclides in aqueous radioactive waste disposals is an indicator of fuel failures.

380 **Strontium-89 and strontium-90** are fission products normally contained within the fuel cladding. If there are any fuel defects, strontium radionuclides can pass into the primary reactor coolant but strontium is less mobile than caesium. We accept that strontium radionuclide production cannot be minimised at source but should be contained. We have commented on the integrity of the cladding above under 'noble gases'. Any released strontium radionuclides should remain in the aqueous effluent and be effectively removed by the filters and demineralisers in the LWPS. EDF and AREVA claim that strontium radionuclides cannot be detected in releases from currently operating nuclear power plants in France(PCERsc8.4s5.1). We consider strontium radionuclide discharges to the environment will be insignificant and do not consider them further in our assessment.

381 **Our assessment concluded that the UK EPR uses BAT to minimise the production of other radionuclides but we expect a review of the BAT assessment on minimising the production of activated corrosion products for the following matters where possible improvements were identified in the PCER, see above:**

a) **corrosion resistance of steam generator tubes;**

b) **electro-polishing of steam generator channel heads;**

c) **specification of lower cobalt content reactor system construction materials;**

d) **further reducing use of stellites in reactor components, in particular the coolant pump;**

and incorporation of the improvements into the design where appropriate (assessment finding UK EPR-AF04)

7.3.6 Radioactive actinides

382 Radioactive actinides (in particular plutonium, americium, curium and uranium) are formed by a series of activations of uranium (PCERsc6.1s2.8):

a) in the fuel but will only appear in the coolant if there are fuel defects;

b) in any trace surface contamination of the fuel pins by fuel (called 'tramp uranium');

c) in impurities in the fuel cladding and in other materials.

They are potentially significant to the impact of disposals as they are alpha emitters.

383 EDF and AREVA claim that the sources of actinides from surface contamination or impurities are not significant compared to the potential for release through fuel defects.

384 EDF and AREVA claim that improvements in fuel reliability through design and quality manufacture minimise fuel leaks and, therefore, the potential for actinide discharges. They also claim high removal efficiencies for actinide particulates in the filters in the coolant purification system of the chemical and volume control system.

385 EDF and AREVA provided us with an internal report examining data about alpha emitters in a number of operating plants with cladding defects. The report confirms the high removal efficiencies claimed. EDF and AREVA claim that their operational experience shows that even with fuel defects they have not been able to detect alpha emitters in samples taken at the points of discharge for predecessor plants to the UK EPR. They therefore did not wish to provide discharge estimates for alpha

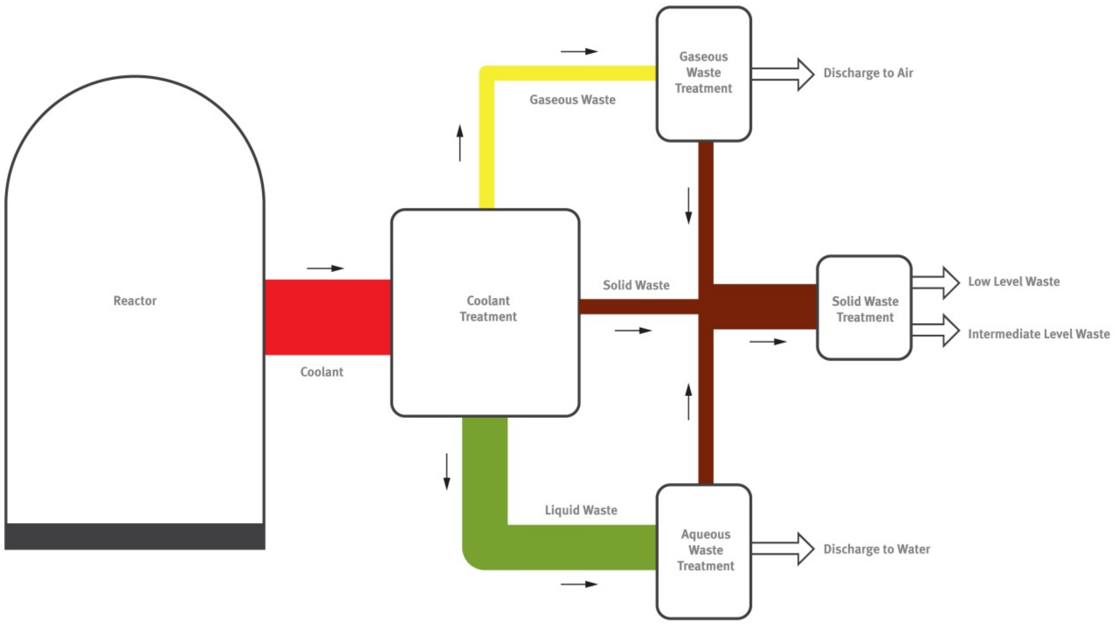
emitters and do not consider disposal limits are required for alpha emitters.
In the UK EPR, the '*absence of gross alpha activity*' will be confirmed by analysis of samples taken from the gaseous discharge and from each tank of aqueous effluent discharged. (PCERsc7.3s1.1.3.2 and s 2.1.4.1)

386 **Our assessment concluded that radioactive actinides will not contribute significantly to discharges or radiological impacts. We do not consider it proportionate to assess actinides in detail and will not consider them in limit setting. The presence of actinides in discharges will be detected by the various monitoring arrangements that will be implemented for the UK EPR.**

7.4 Processing of radioactive materials in the UK EPR

387 This section describes how radioactive materials are processed and handled in the UK EPR. We expect the options chosen for a new nuclear power plant to minimise the overall impact of their discharges on people and the environment. (Statutory Guidance (DECC, 2009a) and our REPS (Environment Agency, 2010c) RSMDP7)

388 The majority of radioactive materials that will form waste are initially contained within the reactor coolant. Therefore, the options used to treat coolant are important factors that determine the form of radioactive waste and its ultimate disposal to solid, aqueous and gaseous waste routes. Following application of the waste hierarchy, the preference for waste disposal is to concentrate and contain the activity (preferably as a solid). Where this is not possible (i.e. considering the balance between worker dose, practical feasibility of "concentrate and contain" all streams and costs) an assessment of impact from aqueous or gaseous disposal should be made to determine which technique is preferable.



Conceptual waste flow diagram for a PWR

389 Gaseous radioactivity from radiologically controlled areas within the UK EPR is removed by ventilation systems to reduce occupational exposure. The ventilation systems discharge into the main stack.

7.4.1 Primary circuit – the reactor coolant system (RCS)

390 The reactor coolant system (the RCS) includes the reactor, four steam generators and a pressuriser and contains the coolant. The coolant is essentially water with certain chemicals added for control purposes. To maintain this control, a small flow of coolant from the RCS is sent to the chemical and volume control system (CVCS). The CVCS, in conjunction with the coolant storage and treatment system (CSTS) and the reactor boron and water make-up system (RBWMS) purifies and degasifies the coolant and then adjusts its chemistry by adding or removing chemicals, in particular boron. The coolant is pumped back into the RCS at a rate to maintain the contained volume. (PCERsc1.2s4.2.8)(Flow diagram – PCSRsc9.3s9.3.2 Figure 1)

391 Purification of the coolant is by passing through filters to remove suspended particles and then through demineralisers (ion exchange resins) to remove soluble metal compounds. The filter will remove 99.9 per cent of particles sized at 1 micron or above. These filters and demineralisers remove material that could be made radioactive by activation and also material that has been activated, therefore minimising radioactivity in the coolant. This is important both for protecting workers from radiation and to minimise activity in aqueous radioactive waste produced. EDF and AREVA claim that using filters below 1 micron adds to generation of solid waste (spent filter cartridges) for minimal reduction in the radioactivity of the coolant. The filter elements and spent demineraliser resins need to be replaced at intervals and become solid radioactive wastes that are usually intermediate level waste (ILW). We consider using filters and demineralisers in this system in the UK EPR contributes to BAT to minimise discharges to the environment and is consistent with the principle of ‘concentrate and contain’. (EPRBs3.4)

392 A respondent (GDA119) was concerned that the uncaptured particles (the 0.01% fraction and particles less than 1 micron) would contaminate the environment. Coolant within the CVCS recycles through the reactor system and has no direct route to the environment. A main purpose of the purification described above is to remove non-radioactive materials from the coolant that could be made radioactive within the reactor thus minimising the generation of radioactive particles. Any coolant that is discharged from the reactor system has to pass through the liquid waste processing system, as described elsewhere in this document, before entering the environment.

393 Coolant from the CVCS can be sent to a degasifier if required. This is mainly used before a shut-down or if noble gases are detected (loss of fuel integrity) in the coolant during operation. The gases removed from the coolant are sent to the gaseous waste processing system (GWPS). The gases need to be removed to avoid build-up of radioactivity in the coolant both for protecting workers from radiation and to avoid a surge in discharged activity at shut-downs. We consider availability of the degasifier and the GWPS in the UK EPR as BAT to control the radioactivity of gaseous wastes and minimise peaks of discharge. (PCERsc6.2s1.2.2.1)

394 The boron concentration in the coolant is used to control reactivity in the reactor and is generally reduced over a power cycle (the time before refuelling – usually 18 months for the UK EPR). The CSTS contains an evaporator that separates coolant into water that can be recycled back into the RCS and a boron concentrate that can be reused. We accept that the CSTS within the UK EPR is BAT, as recycling and

reuse of water and boron will minimise the generation of aqueous waste. (PCERsc6.2s2.2.2.5)

395 A coolant storage and treatment system (CSTS) is associated with the CVCS. This contains six tanks that can store water and boron solution for use in the RCS. The tanks facilitate reuse and recycling. There is a route to bleed coolant to the LWPS when necessary to control tritium and carbon-14 content. Coolant volume can be made-up by adding demineralised water. Water is passed through a demineraliser and filter before transfer to the RCS by the CVCS. We consider that the UK EPR uses BAT to reuse and recycle liquids where possible to reduce aqueous effluent volume. (PCERsc6.2s1.1.2.1)

396 The degree of recycling of effluents in the UK EPR design increases degassing. This has the effect of transferring the maximum amount of carbon-14 into the gaseous effluent. EDF and AREVA claim this is BAT, as the impact from gaseous disposal is less than that of aqueous disposal (0.008 $\mu SvGBq^{-1}$ carbon-14 for gaseous is quoted against 0.15 for aqueous). Our assessment supports this claim for the generic site. (EPRBs3.2)

397 The final element of the CVCS is a Volume Control Tank (VCT) with a nitrogen filled headspace. Dissolved gases, particularly noble gases, in the coolant will degas into the VCT headspace which is purged by the Gaseous Waste Processing System (GWPS). The CSTS and RWBMS storage tanks are also purged by the GWPS. The GWPS in the UK EPR is similar to the Konvoi design GWPS and normally recycles the purge gas (a closed loop)(PCERsc6.2sc1.2.3.1). This allows decay of shorter-lived noble gases before discharge. However, during plant start-up or shut-down a portion of the purge gas passes through driers to remove water vapour before entering three delay beds (see our report EAGDAR UK EPR-04s2.5.3).

398 In a predecessor design (the 1300 MWe plant) the Coolant Storage and Treatment System (CSTS) tank has intermediate flushing and this is responsible for some 80% of the tritiated gaseous discharges from these plants (the 20% left owing almost entirely to pools' evaporation). To minimise this source of tritium, the UK EPR uses an alternative system (as used in the predecessor N4 design) for the collection and treatment of primary circuit coolant as this is let down from the circuit over the operating cycle, a closed loop as described above. EDF and AREVA claim that this technique minimises this source of tritium, the bulk of tritium discharges to air from the UK EPR is mainly due to evaporation of tritiated water from the pools (this source being responsible for about 20% of the tritiated gaseous discharges from the 1300 MWe plants). Considering the larger size of the UK EPR pools compared to the 1300 MWe plant pools, PCERsc8.2 Table 1 claims a reduction of 60% in gaseous tritium discharges compared to the predecessor 1300 MWe plant. We accept that the UK EPR design uses BAT to minimise gaseous discharge of tritium.

399 Any leakage from pipes or equipment containing reactor coolant could:

a) cause aerosols containing corrosion products, these would be collected by the ventilation systems and contribute to gaseous radioactive waste;

b) contribute to aqueous radioactive waste by way of the drain systems.

400 EDF and AREVA claim '*reinforced leak-tightness requirements for active parts (pumps and valves) and the recovery of primary coolant leaks*'. Recovery is demonstrated (PCERsc6.2s1.1.2.1) and PCERsc8.2s3.3.1 lists techniques used in the UK EPR to minimise leaks:

a) bellows seals;

b) reduced numbers of welds;

c) double barriers made of a ring joint with a blocked port between the two rings;

d) leak-off lines: pipes placed on valves to enable connection directly to drain system;

e) double packing pressure seals.

Our assessment of techniques concluded that BAT is used on the UK EPR to minimise leaks and, therefore, minimise the potential for producing wastes.

401 There is a system to collect effluents produced in the UK EPR (PCERsc6.2s1.1.2.1). This is part of the nuclear island vent and drain system (NVDS). Effluents from the RCS are collected separately, unless potentially chemically polluted, and recycled into the coolant storage and treatment system for treatment and reuse as coolant. We consider this as contributing to BAT to minimise the volume of aqueous waste requiring disposal.

402 The NVDS collects all other aqueous effluents in a number of drains but maintains segregation to allow the most appropriate treatment before disposal. PCERsc6.4s2.1 Figure 2 shows the principle of routing of effluents. Choices can be made at effluent collection sumps as to route, with uncontaminated effluent sent directly to a discharge tank or contaminated effluent to an appropriate tank at the front end of the liquid waste processing system. Again, we see this as contributing to BAT as it allows the most effective treatments to be applied to minimise activity on disposal.

7.4.2 Secondary circuit

403 The secondary circuit contains boiler quality water that is made into steam in the steam generators (SGs). The steam drives turbines that generate electricity. The steam is condensed after the turbines and the condensate water reused. In the event of any tube leaks in the SGs, the secondary circuit water could be contaminated with radioactivity, in particular tritium. There is a blowdown (bleed) from the secondary circuit used to control the solids content of the water. This is normally passed through a filter and demineraliser and recycled. If the blowdown cannot be recycled, it is sent to a discharge tank for monitoring before disposal without further treatment. SG construction has been improved to minimise potential for leaks. There is no additional generation of tritium by this route. We accept the improvements to the SG construction as contributing to BAT to minimise the potential for a radioactive discharge by this route. (PCERsc6.2s1.1.2.3)

7.4.3 Ventilation systems

404 Ventilation systems should include appropriate treatment systems to remove and collect airborne radioactive substances before they are discharged to the air. (Our REPS (Environment Agency, 2010c) ENDP16)

405 All radiation controlled areas within the UK EPR are served by ventilation systems (PCERsc6.2s1.2.3.2). This helps to minimise radiation exposure to the workforce. Radioactive materials can occur in the ventilation air from trace leakage from active systems, EDF and AREVA claim '*reinforced leak-tightness requirements*' (PCERsc8.2s3.3.1), see chapter 7.4.1 above.

406 The UK EPR design has minimised the potential for radioactivity to enter ventilation systems or the air by:

a) removing air operated valves from the reactor building (RB). This means that there is no excess air entering the RB and no need to vent this during the power cycle. This removes a possible source of gaseous radioactive waste;

b) installing a metal skin inside the reactor building to prevent leakage of radioactive gases.

407 The main source of tritium for gaseous disposal is tritiated water evaporating from the surface of fuel pools and entering the ventilation systems. Disposal is to the main stack.

408 Ventilation systems include high efficiency particulate air (HEPA) filters and iodine traps that are brought into use if iodine radionuclides are detected in discharged air. BAT for the filters and iodine traps is covered in chapter 8 of this document.

7.5 Containment of radioactive liquids in the UK EPR

409 Radioactive liquids will be produced in the UK EPR. We expect these liquids to be contained within the facility to prevent contamination of land or groundwater (with consequent potential for the production of large volumes of radioactive waste) under normal conditions. Under fault conditions, we expect a design to use BAT to minimise the probability of contamination occurring and the extent of contamination. (Our REPS (Environment Agency, 2010c) RSMDP10 and CLDP1)

410 Under the Environmental Permitting Regulations 2010 (EPR 10), a permit is required for the deliberate discharge of certain substances, including radioactive substances, to groundwater, with the aim of preventing or limiting pollution of groundwater.

411 EDF and AREVA claim that there is no likelihood of direct or indirect discharges of radioactive substances to groundwater. In that case, a UK EPR should not need to be permitted by us for a discharge to groundwater under EPR 10.

412 EDF and AREVA claim that the UK EPR has several levels of techniques to contain liquids within the nuclear island and prevent contamination of land and groundwater (PCER sc8.3s3):

a) primary containment:

   i) metallic components are designed, manufactured and erected to ensure they remain leak-tight over the lifetime of the facility (see PCSRsc3.2s1 and Table 3, PCERsc8.2s3.3.1);

   ii) concrete pools, tanks and sumps that will hold liquids will be fitted with a metallic liner.

b) secondary containment:

   i) any leaks that do occur will be contained inside buildings or piping galleries;

   ii) buildings are erected on a concrete raft with floor and part of walls coated to contain spills;

   iii) pipes that run outside buildings will be in leak-tight concrete galleries that can be inspected.

c) valves are installed on liquid circuits to allow isolation of any section with a leak;

d) leak collection systems operate in the nuclear island and the turbine hall. The sumps of these systems are fitted with systems to warn the operator, through the main control and instrumentation (C&I) system, of massive liquid inlet. An alarm is also given in the event of excessive sump pump run time, which could indicate a continuous smaller leak;

e) drains that pass through the base concrete are of a double wall construction, the inner pipe carrying effluent is within a larger outer pipe. When drain pipes enter sumps, a special receptacle is placed to collect any leakage in the outer pipe and give a visual indication of a leak in the inner pipe;

f) sumps are fitted with visual inspection tubes so that any leakage from the liner into the concrete pit can be seen;

g) monitoring throughout the life of the plant:

   i) inspection of equipment during maintenance;

   ii) monitoring of groundwater.

413 EDF and AREVA state that concrete pools, in particular the spent fuel pool, and tanks in the nuclear island are fitted with a system to detect, locate and drain leaks from the liner of the concrete tanks.

414 EDF and AREVA claim that concrete tanks in the nuclear island are oversized to reduce the risk of overflow.

415 Effluents are collected at the front end of the liquid waste processing system (LWPS) by tanks. EDF and AREVA claim that these, together with the discharge tanks, are sized to offer substantial hold up capacity to cover all reactor operating scenarios and represent BAT for storage of effluents on the UK EPR. (PCERsc8.2s3.3.4 and PCERsc6.4s1.1)

a) Floor drain storage – 2 x 75 m^3 steel tanks;

b) Process drain storage – 2 x 100 m^3 steel tanks;

c) Chemical drain storage – 2 x 160 m^3 steel tanks;

d) Distillates storage – 2 x 100 m^3 steel tanks.

416 EDF and AREVA provided us with a document that gives design information for these tanks. The tanks are:

a) of stainless steel to design standard EN 14015;

b) have high level alarms;

c) are within a concrete bund of 440 m^3 available volume (our requirement is greater than 110 per cent volume of largest tank, that is greater than 176 m^3).

Our assessment concluded that the UK EPR design, in terms of LWPS front end tank design and bunding, uses BAT.

417 EDF and AREVA state that the tank volumes were determined using operational feedback data from predecessor plants. They predict total volume of effluent for the UK EPR as 12,000 $m^3\ y^{-1}$. The tanks are operated in pairs, with one filling while the contents of the other are processed through the LWPS. EDF and AREVA claim that the emptying period is designed to be shorter than the filling period, allowing for operational fluctuations in effluent produced, therefore contingency capacity is not required. There is the possibility to transfer effluent to the reserve ExLWDS tanks (see next paragraph) in the event of any problems. The length of fill periods will be variable depending on operational factors. EDF and AREVA are still carrying out studies to define UK EPR fill period ranges.

418 The discharge tank arrangements for the UK EPR will need to be developed for each specific site. The reference case has a set of discharge tanks outside the nuclear island:

a) LRMDS tanks – collecting effluent from the LWPS with a peak maximum radioactivity concentration (based on predecessor plant experience) of 7 MBq l^{-1}, mostly tritium. This would not represent discharge concentrations, effluent can be recycled through the LWPS until acceptable for discharge.

b) ExLWDS tanks – reserve in case of LWPS or outfall problems, normally empty;

c) SiteLWDS tanks – collecting effluent from radiologically uncontrolled areas, usually uncontaminated. Tritium contamination is possible in the event of leaks from the primary to secondary systems with an expected maximum level of 1.9 MBq l^{-1}.

419 EDF and AREVA say that discharge tank design will need to take account of site-specific factors. They provide information from the Flamanville site (comprising two existing 1300 MWe reactors, one EPR in construction and another possible EPR in the future) where tanks will be:

a) 6 LRMDS tanks, 3 ExLWDS tanks and 4 SiteLWDS tanks, each of 750 m^3 capacity (the number and sizing of tanks will be a site-specific matter);

b) of concrete construction with a leak tight, reinforced liner;

c) fitted with high level alarms;

d) fitted with overflow pipes to the other discharge tanks.

420 We require the tank design to be BAT to contain the low activity level liquid effluents. We would not require additional containment such as bunding, but will require details of construction techniques and liner specification at site-specific permitting. We would inspect tanks during construction and would expect to see the operator implement a test and maintenance programme to ensure the tanks remain leak tight.

421 EDF and AREVA will recommend that operators implement procedures for inspecting equipment through the life of a UK EPR to ensure it remains leak tight. These should include:

a) condition of pipework (lagging to be removed where necessary);

b) mechanical damage;

c) operation and integrity of pipe supports;

d) indication of leaks;

e) defects in threaded connections, measuring devices and impulse lines;

f) vibration, excessive noise.

422 EDF and AREVA will recommend that operators of a UK EPR should establish a network of boreholes for sampling groundwater during construction. The network should remain in place during operation and be used to monitor groundwater quality and detect any contaminants that inadvertently reach the water table. We commend this as good practice for reassurance, and recommend that operators contact us at the early stages of site-specific designs so that we can advise on the appropriate location and construction of boreholes. Operators should also develop a conceptual site model[6] for each specific site to help location of boreholes.

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[6] Conceptual site model is the term we use for a '*textual and / or graphical representation of the relationship between pollutant source, pathway (the route through different layers of ground) and receptor (groundwater)*'.

423 **Our assessment concluded that the UK EPR uses BAT to contain liquids and prevent contamination of groundwater in normal operation. The techniques used should also minimise contamination under fault conditions. However, the design of the discharge tanks needs to be resolved at the site-specific stage, with an associated demonstration of BAT for size (enough capacity to cover all reactor operating scenarios) and leak-tight construction (assessment finding UK EPR-AF06).**

8 Gaseous radioactive waste disposal and limits

8.1 Conclusions

424 Our conclusions remain unchanged since our consultation.

425 **We conclude that the UK EPR utilises the best available techniques (BAT) to minimise discharges of gaseous radioactive waste:**

a) **during routine operations (subject to assessment finding UK EPR-AF07) and maintenance;**

b) **from anticipated operational events.**

426 **We conclude that the gaseous discharges from the UK EPR should not exceed those of comparable power stations across the world.**

427 Ten respondents to our consultation generally supported our conclusions. Responses relating to specific topics are addressed in the following sections.

428 As part of our assessment we identified the following assessment finding:

a) Future operators shall, before the commissioning phase, provide an assessment to demonstrate that proposed operational controls on the fuel pool are BAT to minimise the discharge of tritium to air. (UK EPR-AF07)

8.2 Gaseous disposal limits

429 We conclude that any operational, single UK EPR unit should comply with the limits and levels set out below for the disposal of gaseous radioactive waste to air. The limits and levels will be the starting point for any site-specific permit, but will be reviewed as part of the site permitting process based on any additional information provided by a future UK EPR operator. The limits would also be reviewed periodically thereafter, as data becomes available from operational UK EPR reactors.

Radionuclides or group of radionuclides	Proposed annual limit GBq	Proposed Quarterly notification level GBq
Tritium	3000	200[7]
Carbon-14	700	100
Iodine-131	0.4	0.04
Noble gases	22500	2250
All other radionuclides (excepting tritium, carbon-14, iodine radionuclides and noble gases)	0.05	0.027

430 As part of GDA, we are proposing both annual discharge limits and quarterly notification levels (QNLs). Annual limits will probably be expressed as a 12-month rolling average in any permit we may issue. The general principles and methodology for limit setting are set out in our guidance (Environment Agency, 2005), and are consistent with the Government discharge strategy which states '*in setting discharge limits, the Regulators will have regard to the application of best available techniques (BAT)*'. (DECC, 2009b).

431 An individual respondent (GDA126) particularly supported our use of the methodology as it identifies limits to be set based on risk.

432 Attendees at our stakeholder seminar queried how limits were set and why they are different for the different designs. We asked EDF and AREVA to provide us with design basis estimates for discharges of gaseous radioactive waste that should include normal operational events such as start-up, shutdown, refuelling and maintenance (reference 2.2 P&ID). These were the 'expected performance' values given in the table below. These were the starting point for determining limits, our methodology allows the addition of contingencies to allow for such things as uncertainty (an EPR has not yet operated so all figures are predictions) or infrequent but foreseeable events. The methodology also allows a factor to be applied to the expected value (usually x2 for a new plant) so that a limit is somewhat above the normally expected value to allow for operational variance and measurement accuracy. EDF and AREVA provided their 'maximum' values as proposed limits. We reviewed the basis of both sets of values to decide ourselves the right limit to set. The two designs considered in GDA are of different sizes (UK EPR 1735 MWe and AP1000 1117 MWe) and have some differences in how wastes are processed into the gaseous, aqueous or solid paths and therefore limits should not be directly compared between designs.

433 Some attendees at our stakeholder seminar asked if Requesting Parties were happy with the limits we set and how claims regarding limits are assessed by us. We set limits based on information provided and our methodology. We shared initial proposals for limits with EDF and AREVA and they provided some additional information to justify their claims, however the final decision is ours.

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[7] This figure has increased from 150 GBq since consultation – see reasoning below.

434 Normally, we would use operational experience from a reactor in setting QNLs, but as the UK EPR is not yet operating anywhere in the world, we do not have that information. Therefore, we have used EDF and AREVA's 'expected performance' as a basis to set the QNLs. These will be challenging for a new reactor as we wish to assure ourselves that BAT is being used to minimise discharges in accordance with Government expectations (BERR, 2008a). It is possible that with early operational feedback from reactors now under construction we may need to review and revise the QNLs either at the site permitting stage, or during the early years of operation.

435 Two respondents, both future operators (GDA106 and GDA127), were concerned that our rationale for setting QNLs as well as not being able to be based on operating data did not take account of operator or site-specific factors. We accept that different operators may have different waste management practices and there may be site-specific factors. Operators may propose their own basis for QNLs when applying for their permit. We have proposed an initial set of QNLs to show that we intend QNLs to reflect actual predicted discharges and provide notification to us for unusual discharges. The limits have contingencies built in and should not be considered as a starting point for QNLs.

436 An individual respondent (GDA123) considered some QNLs set at too high a level. When we have set a QNL at high level compared to a limit this is because we expect most of an annual discharge to be made in one quarter around a shutdown. We accept this may give us inadequate notification of high discharges in 'normal' operating times, we are considering using two levels of QNL, one for 'normal' operation and one for a shutdown period. This will need to be decided at site-specific permitting when we have the operators' proposed discharge management regime.

437 An individual respondent (GDA126) suggests QNLs should be based on limits but we use QNLs to help us ensure BAT is being used. QNLs should be based on expected normal discharges without any contingencies, a notification will warn us of unusual discharges and the Operator would need to demonstrate that BAT has been used. If BAT is used then limits should be complied with as they are based on BAT.

438 An individual respondent (GDA38) asked that limits and QNLs be kept under review to ensure they are appropriate. We confirm that we review limits and QNLs whenever circumstances warrant this but also on a regular periodic basis.

8.3 Gaseous radioactive discharges

439 In addition to using BAT to prevent and, where that is not practicable, minimise the creation of radioactive waste (as discussed above), we also expect new nuclear power plant to use BAT to minimise the radioactivity of discharges of gaseous radioactive waste and to minimise the impact of those discharges on the environment.

440 The PCERsc3.3s4.1.1.1 describes three origins of gaseous radioactive waste:

a) degassing associated with the primary circuit. This waste will contain the radioactive gaseous products of fission and activation and will enter the gaseous waste processing system (GWPS). The GWPS treats gaseous effluents from the systems serving the reactor coolant system:

   i) the purge system keeps a nitrogen flow through the free volumes of tanks and vessels. The nitrogen purge gas is mostly recovered by the GWPS and reused. During plant start-up or shut-down a portion of the purge gas is sent to a dryer and then three activated carbon delay beds in series before discharge;

ii) the degasification system may be used to treat coolant at shut-down and its waste gases sent to the delay system. (PCERsc6.2s1.2.3.1, diagram PCERsc6.4s3 Figure 1 (page 80)).

b) the ventilation of buildings within the UK EPR that may be contaminated with radioactivity, in particular the nuclear auxiliary building and the fuel building. Ventilation air that may contain radioactive particulates and gases, in particular iodine radionuclides (iodine-131 and iodine-133), is passed through filters and, if iodine detected, iodine traps before discharge;

c) gaseous effluent from the secondary circuit. This would be mainly air collected in the condenser vacuum system that could be contaminated with radioactivity, particularly tritium, in the event of a minor tube leak in the steam generators. The collected gases are filtered before discharge.

441 The box at the end of PCERsc8.2s3.4.6 summarises the EDF and AREVA BAT assessment for gaseous radioactive discharges. The UK EPR design has:

a) provided absorbent charcoal delay beds to reduce the activity of short lived radioactive gases such as xenon and krypton;

b) included dry high efficiency particulate air (HEPA) filters (efficiency 99.97 per cent) on ventilation discharges;

c) used carbon adsorption to reduce discharges of iodine radionuclides whenever detected in ventilation discharges;

d) used a semi-closed loop system for the treatment of aerated effluents, its advantages are listed in PCERsc6.3s7.4.1.

442 EDF and AREVA claim that, depending on the level of primary coolant activity, gaseous radioactive discharges from the UK EPR are reduced by 20 per cent for noble gases and iodine radionuclides and by 15 per cent for other fission and activation products as compared to the predecessor 1300 MWe design allowing for the increase in energy production. (PCERsc6.3s7.4.1).

443 PCERsc3.3s4.1.2 Table 4 states that the UK EPR will make radioactive discharges to air through the main stack as given in the table below. We have added to that table our proposed disposal limits and QNLs, which are explained further later in our document.

Category	Annual expected performance excluding contingency (GBq)	Maximum annual gaseous radioactive discharge (GBq)	Proposed Environment Agency annual limits (GBq)	Proposed Environment Agency QNL (GBq)
Tritium	500	3000	3000	200
Carbon-14	350	700	700	100
Iodine-131	0.0228	0.18	0.4	0.04
Total iodine radionuclides	0.05	0.4	None	
Noble gases	800	22500	22500	2250
All other radionuclides (excepting tritium, carbon-14, iodine radionuclides and noble gases)	0.004	0.12	0.05	0.027

444 Some respondents sought clarification of the terms used above.

a) The ‘annual expected performance’ is the estimate of discharges from the UK EPR provided by EDF and AREVA based on ‘best quartile’ of predecessor plant allowing for design improvements. It is a ‘best’ estimate of the annual average discharge containing no contingencies.

b) The ‘maximum’ is the limit proposed by EDF and AREVA for a UK EPR including contingencies to cover all foreseeable events likely to occur in normal operation. We do not always accept the level of contingency requested.

445 The above estimates are expanded into individual radionuclides in the PCERsc3.3s4.1.2 Table 5. We are content that these represent the significant radionuclides potentially discharged to the air.

446 We will set limits and levels on the quantities of radioactivity that can be discharged into the environment where these are necessary to secure proper protection of human health and the environment. We have assessed the information within the PCER against the criteria in our limit setting guidance (Environment Agency, 2005) as follows:

a) critical group dose greater than 1 μSv y^{-1}: carbon-14 at 5.6 μSv y^{-1};

b) discharge exceeds 1 TBq y^{-1}: tritium and noble gases;

c) indicator of plant performance:

   i) iodine radionuclides for fuel pin failures, we will use iodine-131 as an indicator;

   ii) ‘all other radionuclides’ to be monitored as particulates will confirm performance of filters in the ventilation systems.

447 We have set out our proposed disposal limits for tritium, carbon-14, noble gases, iodine-131 and other radionuclides in the table above. The definition of ‘all other

radionuclides' will be specified more completely in our permit with reference to the monitoring technique to be used.

448 PCERsc6.3s7.2 to s7.5 quantifies disposals, these are given as 'expected performance' that has no allowance for any contingencies and 'maximum' (we have taken as the proposed disposal limit) that allows for contingencies to cover situations foreseeable in normal operations but not any incidents. The PCERsc6.2s1.2.2 covers the nature and treatment of the gaseous disposals. We have summarised the PCER and EPRB information below for individual radionuclides and groups and detailed our limit proposals.

449 **Our assessment concluded that:**

a) **all sources of gaseous radioactive waste have been identified;**

b) **the nature and form of gaseous radioactive waste has been identified in enough detail to demonstrate that treatment processes and disposal routes can be envisaged for all gaseous radioactive waste;**

c) **the data provided by EDF and AREVA relating to the sources of gaseous radioactive waste are comprehensive, justified and reasonable at the GDA stage.**

8.3.1 Tritium

450 The main sources of tritium for gaseous disposal are tritiated water evaporating from the surface of the in-containment refuelling storage water tank (IRWST) and the spent fuel pool which are collected by the ventilation systems. EDF and AREVA claim maximum losses by evaporation are 350 GBq y^{-1} from the pool and 500 GBq y^{-1} from the IRWST, with realistic values below these figures. Disposal is to the main stack.

451 EDF and AREVA claim that ventilation system design reduces evaporation of tritium but do not provide evidence or quantification of this.

452 EDF and AREVA say that evaporation of tritium from the pool and the IRWST depends on the ambient temperature and hygrometry. Operating conditions need to be optimised by the operator at the site-specific stage between the health and safety of workers in the building and reduction of evaporation of tritium.

453 We will require a BAT case for controlling tritium resulting from evaporation in the UK EPR in applications for site-specific permitting.

454 Tritium will also be present in the gaseous effluent from the primary coolant treatment systems. This effluent is processed in the gaseous waste processing system. We have noted above that the GWPS minimises discharge of tritium to air.

455 Another possible pathway for tritium discharge is in the event of leaks in or diffusion through the tubes between the primary and secondary circuits in the steam generators. The steam in the secondary circuit may then contain some tritium, the steam is condensed after passing through the turbines and the condenser off-gas is collected and feeds into the ventilation systems.

456 EDF and AREVA review gaseous abatement techniques (EPRBs3.3) but do not consider any represent BAT:

a) decay by delay is not an option as the half-life of tritium is 12 years;

b) filtration does not affect tritium in gaseous effluent;

c) oxidising the gaseous effluent and then adsorption of the tritiated water produced on molecular sieve is possible. The sieve could be disposed of as solid waste or the tritiated water desorbed by heat and discharged as aqueous effluent. The technique is not currently in use, the solid waste option would produce volumes of radioactive waste needing disposal, the desorption option would be complex. Cost would be disproportionate to the benefit in reducing the gaseous impact.

d) scrubbing with chilled water will move tritium to aqueous effluent. The low level of tritium in the gaseous route (2 – 3 per cent of UK EPR total) and inefficiency of the scrubbing process mean any cost would be disproportionate to the benefit in reducing the gaseous impact.

457 Tritium discharges have a relatively low impact on the environment (see below – 0.26 µSv y^{-1} to an infant). We, therefore, agree that using any of the gaseous abatement techniques considered is disproportionate for the UK EPR.

458 **Our assessment concluded that the UK EPR uses BAT to minimise discharges of gaseous tritium, although we expect the operator to demonstrate that controls on the fuel pool are BAT to minimise the discharge of tritium to air at the site-specific stage (assessment finding UK EPR-AF07).**

459 An individual respondent (GDA27) asked if there was a problem with the fuel pools while another (GDA106) said that a proportionate approach was needed to gaseous discharge of tritium as its impact was so low. We do not consider there is a problem with gaseous discharge of tritium from the fuel pool, it is that operators can optimise the ventilation and temperature control of the pool to reduce discharges. We will require evidence from future operators that their proposal for pool management is BAT but the detail of evidence need only be proportionate to the low impact, see assessment finding UK EPR-AF07.

460 EDF and AREVA estimated the expected performance value of 500 GBq y^{-1} using operational feedback from currently operating similar reactors, allowing for differences in pool surface area.

461 EDF and AREVA cited current limits for similar but smaller plants and operational experience of an annual maximum reaching 1000 GBq to propose a maximum annual disposal for the UK EPR of 3000 GBq.

462 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to atmosphere of tritium is 100 to 3600 GBq per year (GBq y^{-1}) for a 1000 MWe power station (see Annex 4). We conclude that the gaseous discharge of tritium from UK EPR at the 'expected performance' of 500 GBq (290 GBq normalised to 1000 MWe) is comparable to other power stations across the world.

463 The Committee on Medical Aspects of Radiation in the Environment (COMARE) (GDA129) suggested that as '*part of a new generation of plants, it might be expected that discharges would be lower than existing facilities, rather than 'within the range of historic discharges' which seems to be the criterion being applied by EA*'.

464 We discuss the data we used to confirm discharges were comparable to current power stations in Annex 4. We had difficulty that data were very variable and affected by matters such as shutdowns for periods that were not known. Also the data for the UK EPR are based on predictions as no EPR is yet running. Therefore attempting comparison to show lower discharges for the UK EPR was not possible. We have indicated throughout this document areas where the UK EPR has been improved and discharge reductions are expected.

465 The monthly disposal profile is stated as unlikely to present major fluctuations. Values at 10 per cent of the annual are quoted: 50 GBq/month 'expected performance' and 300 GBq/month 'maximum'.

466 The radiological impact from the 'maximum' disposal of tritium to air is stated as a dose to adults and children of 0.14 μSv y^{-1} and infants of 0.26 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables B, C and D.

467 COMARE (GDA129) note that the recent report of the Advisory Group on Ionising Radiation (AGIR) (November 2007) suggests that current dose estimates for tritiated water are too low. In April 2008 the Health Protection Agency advised us on the implications of the AGIR report on tritium for our regulatory dose assessments. Their advice was that the current dose assessment methods should remain unchanged – they endorsed our approach to the assessment of doses from tritium; that is, the use of standard International Commission on Radiological Protection (ICRP) dose coefficients. The impacts for tritium provided by EDF and AREVA and ourselves throughout this document are therefore based on current standard ICRP recommendations.

468 The HPA identified examples of when the AGIR recommendation could be taken into account, which would be for estimates of dose and risk to individuals, for the purposes of calculation of probability of cancer causation, including more precise relative biological effectiveness (RBE) values and risk factors specific to those individuals.

469 EDF and AREVA propose a gaseous disposal limit for tritium of 3000 GBq y^{-1}. They state that as a new design there are some uncertainties as to the actual evaporation rates leading to tritium disposals and that an improved monitoring method for tritium may report higher values than historic data from existing reactors. Therefore, the headroom of 2500 GBq above the 500 GBq 'expected performance' is proposed until operational experience of an EPR is available.

470 We concluded above that the UK EPR uses BAT to minimise the gaseous discharge of tritium (subject to assessment finding UK EPR-07) with an 'expected performance' value of 500 GBq y^{-1}. The limit set should allow some headroom above this value to allow for foreseeable contingencies. We have considered the operational data presented in PCERsc6.3 Appendix A-24 and A-25 for previous similar plant and have taken 1000 GBq y^{-1} as a worst-case operational estimate. Allowing for the larger size of the UK EPR and a contingency factor, we will accept the proposal to set the annual disposal limit at 3000 GBq.

471 We consider that a quarterly notification level based on the 'expected performance' (500 GBq y^{-1}) and the stated monthly estimate of 10 per cent of annual should be set plus an allowance for operational fluctuations. That is 3 x 50 = 150 GBq/quarter, we will add 50 GBq as an allowance giving a QNL of 200 GBq. This should highlight adverse trends in disposals and require an operator to demonstrate that BAT is still being applied if a QNL is exceeded.

472 A respondent (GDA163) noted that the QNL we proposed at Consultation (150 GBq) was low and could imply a restriction in operation. We recognise we should have allowed a margin over the expected discharge to allow for operational fluctuations, this is corrected above.

8.3.2 Carbon-14

473 As described in our chapter 7, the main source of carbon-14 is the activation of oxygen and nitrogen in the reactor coolant. The carbon-14 is mainly present as the dissolved gases methane (CH_4 – about 80 per cent) and carbon dioxide (CO_2 – 20 per cent). A portion of the coolant continually passes through the chemical and volume control system where dissolved gases are sent to the gaseous waste processing system (GWPS). The GWPS does not remove any carbon-14. EDF and AREVA state that 80 – 95 per cent of the carbon-14 in the coolant will discharge as a gas with 5 -20 per cent remaining in aqueous or solid waste. (PCERsc6.3s7.3.1.3)

474 EDF and AREVA have considered techniques to minimise the gaseous discharge of carbon-14 (EPRBs3.2), in particular:

a) decay by delay is not an option as the half-life of carbon-14 is 5710 years;

b) thermal oxidation to ensure all carbon-14 is converted to carbon dioxide (CO_2) followed by scrubbing, for example, with sodium hydroxide solution, to remove the CO_2 as a carbonate. The carbonate can be converted to a solid waste for disposal;

c) thermal oxidation, as above, followed by CO_2 absorption in a cooled fluorocarbon or ethanolamine solvent. The issue of dealing with the absorbed CO_2 is not resolved;

d) thermal oxidation, as above, followed by CO_2 adsorption on molecular sieve. The issue of dealing with the molecular sieve after saturation is not resolved;

e) thermal oxidation, as above, followed by freezing out the CO_2. The issue of dealing with the removed CO_2 is not resolved.

475 EDF and AREVA state that while there are potential techniques for reducing carbon-14 in gaseous effluents, none are currently used on operational power reactors and they do not, therefore, represent world best practice. Also, some are not technically developed enough to be used in a PWR. They cite the IAEA Technical report 421 that concludes that carbon-14 removal methods are costly and require high energy consumption, but do not provide any cost or energy estimates for applying any techniques to the UK EPR. EDF and AREVA consider that the impact from the gaseous disposal of carbon-14 is low (a maximum of 5.6 μSvy^{-1} for an infant) and conclude that no technique is BAT for use in the UK EPR.

476 **Our assessment confirmed that no techniques appear to be BAT at this time for reducing carbon-14 in gaseous discharges from a PWR. We concluded that the UK EPR uses BAT to minimise the discharge of carbon-14 to air.**

477 EDF and AREVA predict an 'expected performance' value of 350 GBq y^{-1} based on the 444 GBq y^{-1} source term, assuming some 80 per cent of carbon-14 produced goes to air. They state that the split of carbon-14 between solid / aqueous and gas is uncertain. Also the level of dissolved nitrogen in the coolant may increase from 10 ppm (value used for source term). Therefore, they propose a maximum annual disposal for the UK EPR of 700 GBq. This value is supported by operational data from predecessor KONVOI reactors.

478 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to atmosphere of carbon-14 is 40 to 350 GBq y^{-1} for a 1000 MWe power station (see Annex 4). The 'expected performance' gaseous discharge of carbon-14 from UK EPR at 350 GBq (203 GBq normalised to 1000 MWe) is within this range. We

conclude that gaseous discharge of carbon-14 is comparable to other power stations across the world.

479 EDF and AREVA were unable to provide a monthly discharge profile but did provide quarterly data based on operational feedback (PCERsc6.3s7.3.3). Discharges are affected by power output and factors such as shut-downs. They are variable and a significant portion of annual discharge can occur in one quarter. Values of 100 GBq/quarter 'expected performance' and 300 GBq/quarter 'maximum' are quoted.

480 The radiological impact from the 'maximum' disposal of carbon-14 to air is stated as a dose to adults of 2.9 µSv y^{-1}, to children of 3.2 µSv y^{-1} and infants of 5.6 µSv y^{-1} – from PCERsc11.1 Annex 3 Tables B, C and D, corrected from 900 (the 'maximum' initially quoted) to 700 GBq y^{-1}.

481 A respondent (GDA158) states that the effective half-life of carbon-14 in the atmosphere is a lot less than its actual half-life as it is absorbed in the formation of sediment beds. We acknowledge this as fact.

482 We accepted above that the UK EPR uses BAT to minimise the gaseous discharge of carbon-14, with an 'expected performance' value of 350 GBq y^{-1}. We accept the headroom proposed of 350 GBq y^{-1} to allow for the uncertainty of split between gas and liquid and level of nitrogen in the coolant. We will set the annual disposal limit at 700 GBq.

483 We consider that a quarterly notification level based on the 'expected quarterly performance' of 100 GBq should be set.

484 COMARE (GDA129) noted that carbon-14 dominated the dose impact and recommended carbon-14 be monitored in the discharge. We confirm that we will require a monitoring method specific to carbon-14 to be used on gaseous discharges.

8.3.3 Noble gases

485 Significant quantities of xenon-133, xenon-135 and krypton-85 should only reach the gaseous waste processing system (GWPS) in the event of defects in fuel cladding (discussed in Chapter 7).

486 COMARE (GDA129) make some important points on fuel integrity:
'*Both designs depend to a great extent on the manufacturing quality control and reliability of fuel elements in order to control waste arisings. It will be important to ensure that operators adhere to the intended operating standards over the lifetime of the plant and that it is made mandatory to implement any improvements made by the manufacturers. What arrangements would be available if current manufacturers went out of business? We support the EA approach of using QNLs in order to give early warning of problems arising from fuel assemblies.*'
Our permit conditions require operators to use and review BAT, the scope of which includes fuel integrity matters. There are a number of suppliers of nuclear fuel worldwide and operators are free to select an appropriate manufacturer based on relevant criteria, for example on technical and commercial specifications. Irrespective of who manufactures the nuclear fuel, operators will need to ensure that any fuel used in their reactors meets quality expectations and that its design represents BAT. The QNL we set below is intended to alert our Inspectors to any fuel issues to enable early investigation and possible intervention.

487 The GWPS is designed to minimise the impact of noble gases by delaying their discharge using activated charcoal beds. The noble gases are initially adsorbed but are gradually moved forward by fresh purge gas passing through the beds. The

delay allows the radioactivity to decay (PCERsc6.3s7.4.2.1). Xenon is delayed by 40 days – for xenon-131 with a half-life of 5.25 days this will reduce radioactivity to less than 0.5 per cent of the value entering the GWPS (reduction factor of 200). Krypton is delayed by at least 40 hours giving effective decay of the short-lived radionuclides krypton-85m (reduction factor of 500 claimed), krypton-87 and krypton-88 but not krypton-85 with a half life of 10.72 years. There is a gas drier before the delay beds to optimise their performance and a filter after to prevent any dust from the beds escaping to the air. The gaseous effluent from the GWPS is discharged to the main stack through HEPA filters located in the nuclear auxiliary building. (PCERsc6.2s1.2.3.1)

488 EDF and AREVA provided us with their design calculations, confirming that the activated charcoal in the three beds would achieve the delays promised above, but did not provide a full BAT options appraisal of alternative techniques or bed sizing.

489 **Our assessment confirmed the delay calculations and that delay beds are current good practice. Further, that the impact from noble gases is low (0.047 μSv y^{-1}) so that a full BAT assessment would be disproportionate. We conclude that the UK EPR uses BAT to minimise the discharge of noble gases.**

490 The Institution of Mechanical Engineers (GDA145), while recognising the value of carbon delay beds, warns that these can present a significant fire hazard requiring mitigation by the installation of appropriate fire detection and protection equipment. We have passed this comment to ONR.

491 PCERsc6.3s7.4.2.1 Table 16 gives the expected distribution of noble gas radionuclides based on data from similar predecessor reactors:

Radionuclide	Percentage of total noble gas activity discharged
Krypton-85	13.9
Xenon-133	63.1
Xenon-135	19.8
Argon-41	2.9
Xenon-131m	0.3

492 Argon-41 is discussed above, its source is activation of naturally occurring argon-40 in the air around the reactor and it is sent to the main stack by the ventilation systems. It does not pass through the GWPS but is monitored in the stack before discharge.

493 EDF and AREVA estimated their 'expected performance' value of 800 GBq y^{-1} using operational feedback data from predecessor reactors. This value can only be achieved if there are no fuel cladding failures and a subsequent need to degas the reactor coolant during a reporting year. The operational data is highly variable showing dependency on fuel reliability. EDF and AREVA say that a sizable contingency is needed to allow for continued operation with even a very low level of fuel failure. They propose a 'maximum' of 22,500 GBq y^{-1} – the same as the current limit in France for the 1300 MWe reactor. As the UK EPR will generate 25 per cent more energy, this is effectively a 25 per cent lower limit and reflects the better performance expected of fuel today. (PCERsc6.3s7.4.2.1, s7.4.2.2.1)

494 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to atmosphere of noble gases is 100 to 10,000 GBq y^{-1} for a 1000 MWe power station (see Annex 4). The 'expected performance' gaseous discharge of noble gases from UK EPR at 800 GBq (460 GBq normalised to 1000 MWe) is well within this range. We conclude that gaseous discharge of noble gases is comparable to other power stations across the world.

495 EDF and AREVA say that in normal operation (without fuel leaks or degassing before shutdown) monthly discharges could be below detectable quantities. Monitoring systems would report at detection thresholds and this could be 400 GBq/month. However, with fuel leaks and if the reactor coolant is degassed the monthly discharge could reach 5000 GBq. (PCERsc6.3s7.4.2.2)

496 The radiological impact from the 'maximum' disposal of noble gases to air is stated as a dose to adults of 0.047 µSv y^{-1}, to children of 0.029 µSv y^{-1} and infants of 0.023 µSv y^{-1} – from PCERsc11.1 Annex 3 Tables B, C and D.

497 We conclude above that the UK EPR uses BAT to minimise the gaseous discharge of noble gases with an 'expected performance' value of 800 GBq y^{-1}. EDF and AREVA propose a headroom of 21,700 GBq to allow for some level of fuel cladding failure. In setting limits we accept that predicting an allowance for fuel leaks is difficult. Reactors are designed to run until their next refuelling shutdown with a small number of fuel leaks, and we do not wish to constrain operations when noble gas discharges have so little impact. We stated our range above as up to 10,000 GBq y^{-1} and, using this as a base value, we need to add some contingency to set a limit and to allow for the increased size of the UK EPR. On that basis, we consider the EDF and AREVA proposal reasonable and we will set the annual disposal limit at 22,500 GBq.

498 We consider that a quarterly notification level should be set to give us early indications of fuel cladding failures. Based on our regulatory experience, we will set the QNL at 10 per cent of the disposal limit – 2250 GBq.

8.3.4 Iodine radionuclides

499 As described above iodine radionuclides are formed by fission in the fuel and are normally contained within the fuel cladding. PCERsc6.3s7.4.3.1 says that most of the iodine radionuclides are retained within the liquids going to the liquid waste processing system. Gaseous iodines will enter the gaseous waste processing system (GWPS) with the noble gases as described above. The recirculation of purge gas in the GWPS will allow decay of shorter-lived iodine radionuclides such as iodine-132 and iodine-134. When purge gas is bled off, it passes through delay beds before discharge. While these beds are not targeted at iodine radionuclides, EDF and AREVA claim a delay of 40 days in the delay beds for iodine radionuclides. Iodine-131 has a half-life of 8 days, so a reduction to around 3 per cent of the input value should take place. (EPRBs3.6)

500 The effluent gas from the GWPS is passed to HEPA filters before discharge from the main stack. There is a detection system to pass the gas through activated charcoal iodine traps if high iodine radioactivity is detected. EDF and AREVA claim a decontamination factor of 100 for the iodine traps in systems that operate during fault conditions and 10 for others. (PCERsc6.2s1.2.3.2.1)

501 Any iodine radionuclides coming from leaks in the primary coolant circuit will enter the ventilation systems. These systems will send ventilation air to activated charcoal iodine traps if high iodine radioactivity is detected or as a precaution during certain operations or in case of accidents. (PCERsc6.3s7.4.3.1 Figure 16)

502 **EDF and AREVA did not review other options for minimising iodine radionuclides discharged. However, we do accept using activated charcoal as current good practice for minimising the discharge of iodine radionuclides. As the level of discharge (50 MBq y^{-1}) and subsequent impact (maximum 0.32 μSv y^{-1}) are low, we accept that a detailed BAT assessment would be disproportionate. Our assessment concluded that the UK EPR uses BAT to minimise the discharge of iodine radionuclides to air.**

503 EDF and AREVA calculated an 'expected performance' value of 50 MBq y^{-1} using operational feedback data from predecessor reactors. This may be high as much data showed 'below detection limit'. This value can only be achieved if there are no fuel cladding failures and subsequent release of iodine radionuclides. The operational data for 'maximums' is highly variable, showing dependency on fuel reliability. EDF and AREVA say that a sizable contingency is needed to allow for continued operation with even a very low level of fuel failure. They propose 400 MBq y^{-1} – the same as the current limit in France for the 1300 MWe reactor. As the UK EPR will deliver 25 per cent more energy, this is effectively a 25 per cent lower limit and reflects the better performance expected of fuel today and the improvements made to the GWPS.

504 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to atmosphere of iodine radionuclides is 1 to 2000 MBq y^{-1} for a 1000 MWe power station (see Annex 4). The 'expected performance' gaseous discharge of iodine radionuclides from UK EPR at 50 MBq (29 MBq normalised to 1000 MWe) is well within this range. We conclude that gaseous discharge of iodine radionuclides is comparable to other power stations across the world.

505 EDF and AREVA claim that in normal operation (without fuel leaks) and without shut-downs or maintenance activities, monthly discharges are very low and could be below detectable quantities; a value of 20 MBq is proposed. However, most iodine radionuclides discharges are expected during shut-downs or maintenance activities when large volumes can be processed through the GWPS. If this also happens when there are fuel leaks, the discharge could reach 75 per cent of the maximum annual discharge so the proposed maximum monthly discharge is 300 MBq.

506 The radiological impact from the 'maximum' disposal of iodine radionuclides to air is stated as a dose to adults of 0.039 μSv y^{-1}, to children of 0.078 μSv y^{-1} and infants of 0.32 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables B, C and D.

507 We conclude above that the UK EPR uses BAT to minimise the gaseous discharge of iodine radionuclides with an 'expected performance' value of 50 MBq y^{-1}. The headroom proposed allows for some level of fuel cladding failure – the PCER says past operational experience has seen discharge levels increase by a factor of up to 10 following fuel leaks. We noted above that we would only set a limit against iodine-131 as it has the greatest individual impact of the iodine radionuclides. Also, the impact of iodine radionuclides is low and we wish to provide adequate headroom to avoid constraining operations, so we propose to set the annual disposal limit for iodine-131 at 400 MBq.

508 We consider that a quarterly notification level should be set to give us early indications of fuel cladding failures. Based on our regulatory experience, we will set the QNL at 10 per cent of the disposal limit – 40MBq.

8.3.5 Other radionuclides

509 EDF and AREVA say in PCER sc6.3s7.4.4.1 that other fission and activation products (FAPs) are present in the reactor coolant and can be in aerosols (a dispersion of solid or liquid particles in a gas) produced from equipment leaks or as the coolant is treated in the chemical and volume control system (CVCS). Most FAPs remain in the liquid phase. Aerosols from equipment leaks are picked up by the ventilation systems, these systems have HEPA filters that should effectively remove the aerosols before discharge to the main stack. FAPs can be in the gaseous effluent from the CVCS to the gaseous waste processing system (GWPS). The gaseous effluent from the GWPS passes through HEPA filters before discharge to the main stack.

510 **Our assessment concluded that using HEPA filters in the UK EPR on all gaseous discharges that may contain fission and activation products is BAT.**

511 PCERsc6.3s7.4.4.1 Table 17 gives the distribution of the main fission and activation product radionuclides expected to be found as particulates in the gaseous discharge:

Radionuclide	Percentage of activity in discharged Fission and Activation Products (FAPs)
Cobalt-58	25.5
Cobalt-60	30.1
Caesium-134	23.4
Caesium-137	21.0

512 Caesium is a fission product and should only be detected on fuel cladding failures, cobalt is an activated corrosion product and can be present in trace quantities. Discharges are often below the threshold of detection of monitoring equipment.

513 EDF and AREVA calculated an ‘expected performance’ value of 4 MBq y^{-1} using operational feedback from predecessor reactors. Values of FAPs were below the detection limits of monitoring equipment and the 4 MBq is in essence a threshold of detection value. Peaks of discharge can be seen, however, during shut-downs and maintenance activity and significant contingency should be allowed to cover these operations. EDF and AREVA used the current limit value for their predecessor 1300 MWe reactors of 400 MBq y^{-1} as a start point for proposing the ‘maximum’ discharge. They claim that the UK EPR has improvements over the 1300 MWe reactor with improved HEPA filtration and the source of cobalt has been minimised by using low cobalt content material. The ‘maximum’ proposed is 120 MBq y^{-1} – less than 25 per cent of the 1300 MWe reactors if the increased power of the UK EPR is taken into account.

514 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to atmosphere of fission and activation products is 1 to 1000 MBq y^{-1} for a 1000 MWe power station (see Annex 4). The ‘expected performance’ gaseous discharge of FAPs from UK EPR at 4 MBq (2.3 MBq normalised to 1000 MWe) is well within this range. We conclude that gaseous discharge of FAPs is comparable to other power stations across the world.

515 EDF and AREVA claim that in normal operation (without fuel leaks to contribute caesium) and without shut-downs or maintenance activities monthly discharges are very low and could be below detectable quantities, the ‘expected performance’ value of 0.8 MBq is proposed. However, in a month before shut-down or when maintenance is carried out and allowing for some fuel leaks combined with any treatment failures a much higher value is required for the monthly ‘maximum’. Up to 50 per cent of the annual discharge could occur in a month – 60 MBq is proposed.

516 The radiological impact from the ‘maximum’ disposal of other FAPs to air is stated as a dose to adults of 0.018 μSv y^{-1}, to children of 0.01 μSv y^{-1} and infants of 0.009 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables B, C and D, corrected from previous maximum of 340 to 120 MBq y^{-1}.

517 We have accepted above that the UK EPR uses BAT to minimise the gaseous discharge of other FAPs with an ‘expected performance’ value of 4 MBq y^{-1}. As well as comparing their ‘maximum’ with current limits, EDF and AREVA say that the headroom of an additional 116 MBq y^{-1} allows for a combination of fuel leaks, maintenance operation and a failure of HEPA filtration systems that could increase discharge by 10 to 50 times. (PCERsc6.3s7.4.4.3)

518 We do not consider this approach justified, in particular when operational data provided in the PCERsc6.3 Appendices A-55 and A-56 are taken into account. The highest discharge reported in the six years from 2002 to 2007 was less than 6 MBq y^{-1}. The values reported are often less than 1 per cent of limits. We note that some higher levels, up to 50 MBq y^{-1}, are reported in the PCER but without the context to these numbers we cannot assess whether they represent normal operational variance or events. We set limits to ensure BAT is used. While we allow for contingencies, we believe that, using BAT, a failure of HEPA filtration should be rapidly detected and any ventilation involved should be diverted to functioning equipment quickly. Further, operations that may cause high discharges should not be carried out when key equipment such as HEPA filters are unavailable. Our normal methodology is to take the worst-case discharge from operational experience and then add an appropriate contingency. We have considered the data provided and taken 25 MBq y^{-1} as a worse-case normal operational discharge. We have applied a x2 factor (Environment Agency, 2005) and propose to set 50 MBq y^{-1} as the annual disposal limit.

519 One respondent, a future operator (GDA106), noted that the limit we propose does not allow sufficient contingency for cladding failure at the same time as short term defects in abatement plant. This could pose a disproportionate operational constraint not warranted by the potential impact.

520 NNB GenCo (GDA106) also responded *“….the proposals in the consultation document for limits on ‘other radionuclides’, which include the fission products released following fuel cladding failure, appear unduly restrictive. Minor fuel cladding failures are foreseeable. Since gaseous discharges are continuous, a short-term defect in abatement plant (such as HEPA filters) – even if quickly resolved by diversion to alternative plant – will result in increased discharges if it coincides with a cladding failure event. However, such events should not require disproportionate action such as immediate shut-down, as long as their impact is demonstrated to be below the threshold where, under Environment Agency guidance, further action to reduce dose is required. In accord with this, the consultation document recognises that cladding failure can have small impact, but requires significant headroom within the discharge limits to accommodate this without constraining operation. To account for this contingency, there should be a difference between the discharge limits and the expected best performance. This*

difference was recognised in the Requesting Party's evidence, but it has not been reflected in the proposals for lower limits in the consultation document. We therefore believe that these proposals would represent an artificial and disproportionate constraint, not informed by the specific risks and impacts for any individual site. Instead, we believe that the system of Quarterly Notification Levels (QNLs) is the appropriate tool to ensure that such events are visible to the Environment Agency and to monitor the operator's effectiveness in applying BAT to minimise deviation from expected best performance."

521 We acknowledge both comments but, as noted above, we do not consider that EDF and AREVA have provided adequate evidence to justify an increased limit.

522 We consider that a quarterly notification level should be set to give us early indications of any issues. We will allow one month at 50 per cent of the disposal limit and two months at the 'expected performance' of 0.8 MBq/month and round up to give a QNL of 27 MBq.

523 An individual respondent (GDA119) was concerned that we were not putting a zero limit on alpha-emitting radionuclides and about the sensitivity of detection methods. We discuss the source and type of potential alpha-emitters in chapter 7.3.6 of this document. There is no expected discharge of alpha-emitters but we will require monitoring as a precaution. The monitoring method will be specified by future operators, we will require the best available techniques at time of installation[8]. The use of 'zero' limits is difficult as measurements can usually only be stated as 'below limit of detection' and at very low levels measurements can be affected by trace background interference, a true zero measurement is almost impossible to achieve. We prefer to rely on the standard BAT conditions in our permits that, in this case, would require operators to demonstrate effectively zero discharge of alpha-emitting radionuclides.

8.4 Gaseous radioactive waste disposal to the environment

524 We are satisfied that all significant gaseous radioactive wastes from the UK EPR are collected into the main stack for discharge. The stack will be fitted with continuous monitoring equipment to measure radioactive materials entering the air.

525 The PCER has assumed an 'effective' stack height of 20 m for GDA. The effective stack height allows for factors such as the effect of nearby large buildings causing downwash, which results in discharges reaching the ground closer to the point of discharge than in an open area. The effective height is much less than the actual height – the initial estimate for the UK EPR stack is 60 metres. Dispersion modelling for the generic site gives an annual dose from the 'maximum' gaseous discharge of 4 μSv for an adult or child and 7.8 μSv for an infant (PCERsc11.1s1.3.2.2). The doses are low enough that we accept that the (GDA) stack height is BAT to reduce impact to a minimum. The future operator for each specific site will need to demonstrate by modelling that the stack height proposed

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[8] We are revising our monitoring guidance M11 but this will be available for future operators to apply. We also require monitoring to conform to the European Commission's (EC) recommendation 2004/2/Euratom) on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation. See our joint guidance with SEPA: http://www.sepa.org.uk/radioactive_substances/publications/idoc.ashx?docid=cefd6d99-5000-4fd5-b028-5f8a39efc7a0&version=-1.

will be BAT for adequate dispersion allowing for topography (the surface features of the local land area surrounding the site), local land use and population locations.

526 West Somerset Council and Sedgemoor District Council (GDA155) said that their primary concern was that dispersion modelling should be undertaken based on local topography so as to see any adverse impact. We have noted above that we expect such modelling to be undertaken, the output of the modelling will be a key factor in our determination of site-specific applications.

9 Aqueous radioactive waste disposal and limits

9.1 Conclusions

527 Our conclusions remain unchanged since our consultation. However many respondents were concerned about compliance with the UK's obligations under OSPAR. We undertook more assessment in regard to this topic, a summary is provided in chapter 9.5 below. Our assessment confirmed that the liquid waste processing system (LWPS) design in the UK EPR was BAT to minimise discharges of aqueous radioactive waste but that future operators would need to optimise their use of the LWPS to demonstrate BAT in operations. Two assessment findings were identified and are shown below.

528 **We conclude that the UK EPR utilises the best available techniques (BAT) to minimise discharges of aqueous radioactive waste:**

a) **during routine operations and maintenance;**

b) **from anticipated operational events.**

529 **We conclude that the aqueous radioactive discharges from the UK EPR should not exceed those of comparable power stations across the world.**

530 Six respondents to our consultation generally supported our conclusions. Responses relating to specific topics are addressed in the following sections.

531 As part of our assessment we identified the following assessment findings:

a) Future operators shall, during the detailed design phase, provide their proposals for the operational management of the Liquid Waste Processing System to minimise the discharge of radioactivity from the site so that exposures of any member of the public and the population as a whole are kept as low as reasonably achievable (ALARA) and to protect the environment. The proposals should be supported by a BAT assessment to show that the use of the evaporator, the choice of filter porosity and the demineralisation media have been optimised to minimise the dose to members of the public. The future operator shall also provide evidence that the Water Treatment Systems have sufficient capacity and resilience to cope with all the aqueous radioactive waste arisings consigned to the evaporator by the proposals. The proposals should consider all plant states, including for example outages and unavailability due to maintenance or breakdown. (UK EPR-AF08)

b) Future operators shall, during the detailed design stage, provide a predicted mass balance showing how their proposed aqueous radioactive waste management regime will affect the disposal of carbon-14 to the gaseous, solid or aqueous routes. For each route the form of carbon-14 expected shall be provided. For solid wastes the quantities of each type of waste shall be provided with expected carbon-14 content. (UK EPR-AF09)

9.2 Aqueous waste disposal limits

532 We conclude that any operational, single UK EPR unit should comply with the limits and levels set out below for the disposal of aqueous radioactive waste to the sea (these are unchanged from our consultation). The limits and levels will be the starting point for any site-specific permit, but will be reviewed as part of the site permitting process based on any additional information provided by a future UK EPR operator. The limits would also be reviewed periodically thereafter, as data becomes available from operational UK EPR reactors.

Radionuclides or group of radionuclides	Proposed annual limit GBq	Proposed Quarterly notification level GBq
Tritium	75,000	45,000
Carbon-14	95	9
Cobalt-60	1.5	0.12
Caesium-137	0.5	0.04
All other radionuclides (excepting tritium, carbon-14, cobalt-60 and caesium-137)	3	0.24

533 We have provided information about limit setting and QNLs in chapter 8.3 of this document. Some respondents had comments about this topic and we have dealt with all of these in chapter 8.3 as they were not specific to gaseous or aqueous limits or QNLs. One respondent (GDA126) was particularly supportive of our use of risk based limits.

9.3 Aqueous radioactive waste discharges

534 In addition to using BAT to prevent and, where that is not practicable, minimise the creation of radioactive waste (as discussed above), we also expect new nuclear power plant to use BAT to minimise the radioactivity of discharges of aqueous waste and to minimise the impact of those discharges on the environment.

535 The PCERsc3.4s5.2.2 describes three categories of aqueous radioactive effluent:

a) liquid associated with the reactor coolant, not chemically polluted;

b) spent liquid comprising polluted reactor coolant, chemical effluent and floor drainage;

c) drainage water from the turbine hall including blowdown from the secondary circuit.

536 The PCERsc6.2s1.1.1 gives more detail on the collection of effluents into 3 drain systems:

a) process drain (PD): collects potentially polluted primary coolant that cannot be recycled;

b) chemical drain (CD): collects chemically polluted water from the nuclear auxiliary building, reactor building and fuel building;

c) floor drains (FD) of 3 types:

   i) FD1: collects potentially contaminated leaks and floor washings from controlled areas;

   ii) FD2: collects normally uncontaminated leaks and floor washings from controlled areas;

   iii) FD3: normally uncontaminated leaks and floor washings from outside controlled areas. FD3 is normally sent directly to a discharge tank for non-radioactive wastes (in the site liquid waste discharge system (SiteLWDS)).

537 The effluents from the PD, CD, FD1 and FD2 are collected in separate buffer tanks before treatment in the liquid waste processing system (LWPS). Effluent from the LWPS is collected in disposal tanks (the LRMDS tanks). The contents of these tanks are analysed before disposal to the sea is allowed under a managed procedure.

538 Drainage from the turbine halls is normally sent to the SiteLWDS except for blowdown water from the secondary circuit. This is normally recycled after treatment, but, if recycling is not possible, blowdown is sent to the LRMDS tanks.

539 The UK EPR uses filtration and / or demineralisation and / or evaporation in the LWPS to minimise discharges of aqueous radioactive waste. These techniques are specifically targeted at reducing fission and activation products and are assessed below.

540 PCERsc3.4s5.2.4 Table 1 states that the UK EPR will make radioactive discharges to the sea as given in the table below. We have added to that table our proposed annual disposal limits and QNLs, which are explained later in our document.

Category	Annual expected performance excluding contingency GBq	Maximum annual liquid radioactive discharge GBq	Proposed Environment Agency disposal limits GBq	Proposed Environment Agency QNL GBq
Tritium	52,000	75,000	75,000	45,000
Carbon-14	23	95	95	9
Iodine radionuclides	0.007	0.05	None	None
Cobalt-60	0.18	3	1.5	0.12
Caesium-137	0.0567	0.945	0.5	0.04
All other radionuclides[1]	0.4	6	3	0.24

[1] (excepting tritium, carbon-14, cobalt-60 and caesium-137)

541 PCERsc3.4s5.2.4 Table 2 gives the distribution of fission and activation products in radionuclides discharged as aqueous waste. The most significant are cobalt-60 and cobalt-58. We are content that this lists the significant individual radionuclides that need to be considered.

542 We will set limits and levels on the quantities of radioactivity that can be discharged into the environment where these are necessary to secure proper protection of human health and the environment. We have assessed the information within the PCER against the criteria in our limit setting guidance (Environment Agency, 2005) as follows:

a) critical group dose greater than 1 µSv y^{-1}: carbon-14 at 14 µSv y^{-1} and 'all other radionuclides' at 3.3 µSv y^{-1} (total including cobalt-60 and caesium-137);

b) discharge exceeds 1 TBq y^{-1}: tritium;

c) indicator of plant performance:

   i) cobalt-60 indicates effectiveness of corrosion controls and the filter and demineralisation system in the liquid waste processing system;

   ii) caesium-137 is an indicator of fuel cladding failures.

543 We have set out our proposed disposal limits for tritium, carbon-14, cobalt-60, caesium-137 and other radionuclides in the table above. 'All other radionuclides' will be more completely defined in any permit we issue, for example, '*All other radionuclides means the sum of all radionuclides as measured by the methods defined in this permit except those specified individually in the table*'. We do not consider it proportionate to set a limit for iodine radionuclides as discharge levels and impact are low and measured levels may well be below detection thresholds of monitoring methods.

544 An individual respondent (GDA119) was concerned that there would be additional uncontrolled discharges '*at the 18-month refuelling, repair and maintenance interval*'. The discharges and limits quoted in this document allow for foreseeable events including refuelling shutdowns. All discharges will be monitored and will need to comply with relevant limits at all times.

545 EDF and AREVA state that alpha-emitting radionuclides should not be present in detectable amounts in the aqueous discharge and that the '*absence of gross alpha activity*' will be confirmed by monitoring of each tank of aqueous effluent before discharge. We will not include alpha-emitters as a category for disposal limits.

546 An individual respondent (GDA62) asked for additional information on alpha-emitting radionuclides detection. The detection method will be specified by future operators, we will require the best available techniques at time of installation[9]. There is no expected discharge of alpha-emitters, detection is there as a precaution. The source and type of potential alpha-emitters is described in chapter 7.3.6 of this document. There would need to be significant fuel defects as well as significant failures in the Liquid Waste Processing System (LWPS) before alpha-emitters could be detected at the discharge tanks. There is also a gross gamma activity detector installed in the main discharge line of the UK EPR, this would detect abnormally high radioactivity in discharges due to any upstream failure (gamma-emitting radionuclides in this case act as an indicator for increased levels of all other radionuclides including alpha-emitters). It is wired to valves in the discharge pipes so that at the set detection level the valves will close to prevent discharge. (PCERsc7.3s2.1.4.3)

9 We are revising our monitoring guidance M12 but this will be available for future operators to apply. We also require monitoring to conform to the European Commission's (EC) recommendation 2004/2/Euratom) on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation. See our joint guidance with SEPA: http://www.sepa.org.uk/radioactive_substances/publications/idoc.ashx?docid=cefd6d99-5000-4fd5-b028-5f8a39efc7a0&version=-1

547 PCERsc6.3s6.2 to s6.5 quantifies disposals, these are given as 'expected performance' that has no allowance for any contingencies and 'maximum' (we have taken as proposed disposal limit) that allows for contingencies to cover situations foreseeable in normal operations but not any incidents. The PCERsc6.2s1.2.2 covers the nature and treatment of the aqueous disposals. We have summarised the PCER information below and provided our conclusions following our assessment of that information.

548 **Our assessment concluded that:**

a) **all sources of aqueous radioactive waste have been identified;**

b) **the nature, form and quantity of aqueous radioactive waste has been identified in enough detail to demonstrate that treatment processes and disposal routes can be envisaged for all aqueous radioactive waste;**

c) **the data EDF and AREVA has provided relating to the sources of aqueous radioactive waste are comprehensive, justified and reasonable at the GDA stage.**

9.3.1 Tritium

549 Tritium is present as tritiated water in the reactor coolant. EDF and AREVA state there are currently no available techniques to remove tritium from the reactor coolant. Therefore, to avoid the build up of tritium in the coolant (to reduce radiological hazard), a portion of the coolant must be discharged (and replaced). This is the main source of tritium for aqueous discharge.

550 Tritium can also be found in the water contained in the secondary circuit if there are leaks in the steam generators. Any water drained from the circuit will enter the LWPS and be contained in storage tanks before monitoring and discharge. This discharge route does not affect the overall discharge of tritium.

551 EDF and AREVA review aqueous abatement techniques (EPRBs3.3) but do not consider any represent BAT:

a) decay by delay is not an option as the half-life of tritium is 12 years;

b) filtration has no effect on tritium in aqueous effluents;

c) evaporation is not an option as tritiated water would carry over to the condensate, leaving little in the concentrate for treatment and disposal as solid waste;

d) EDF and AREVA refer to IAEA technical report No. 421 that lists some theoretical techniques that may potentially be used in the future, but none are currently technically developed for PWRs;

e) tritiated water could be collected and cemented to solid waste. This would produce large volumes of solid waste for disposal (probably ILW) and the tritium may not be immobilised effectively;

f) isotopic retention is an undeveloped technique.

552 **Tritium discharges have a low impact on the environment (see below: 0.018 μSvy^{-1} to an adult). Therefore, our assessment confirmed that using any of the aqueous abatement techniques considered is not proportionate for the UK EPR, we conclude that the UK EPR uses BAT to minimise the discharge of aqueous tritium.**

553 The ‘expected performance value’ of 52 TBq y^{-1} and ‘maximum’ of 75 TBq y^{-1} were taken from calculations assuming 91 per cent or 100 per cent power production respectively and various reactor chemistry options (PCERsc6.3s6.2.1.4). EDF and AREVA then reviewed operational experience of predecessor plant to validate the calculations.

554 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to water of tritium is 2 to 30 TBq y^{-1} for a 1000 MWe power station (see Annex 4). The ‘expected performance’ aqueous discharge of tritium from UK EPR is 52 TBq (30 TBq normalised to 1000 MWe). While the UK EPR is at the top of our range, we noted above in chapter 8.3.1 that the UK EPR minimises gaseous discharge of tritium and this does affect aqueous discharges. We conclude that aqueous discharge of tritium is comparable to other power stations across the world.

555 EDF and AREVA state that monthly discharges are related to the time in the generation cycle. Also contingency is needed to allow operational flexibility to delay discharges for a period to allow for maintenance or faults in the LWPS. Values at 25 per cent of the annual are quoted: 13 TBq/month ‘expected performance’ and 18.75 TBq/month ‘maximum’.

556 The radiological impact from the ‘maximum’ disposal of tritium to the sea is stated as a dose to adults of 0.018 μSv y^{-1}, to children of 0.0049 μSv y^{-1} and infants of 0.0017 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables E, F and G.

557 EDF and AREVA propose an aqueous disposal limit for tritium of 75 TBq y^{-1}. The headroom over the ‘expected performance’ of 52 TBq y^{-1} allows for up to 100 per cent production or other management options that may affect tritium discharges. (PCERsc6.3s6.2.2.2)

558 We concluded above that the UK EPR uses BAT to minimise the discharge of tritium with an ‘expected performance’ value of 52 TBq y^{-1}. We accept the headroom proposed by EDF and AREVA as a reasonable contingency factor and we will set the annual disposal limit at 75 TBq.

559 A few respondents, in particular ‘*Stop Hinkley*’ (GDA157) expressed concern with the tritium discharge limits and that we give tritium discharge insufficient importance. We said in chapter 7 that we concluded that BAT is used in the UK EPR to minimise the production of tritium at source. The UK EPR will discharge considerably less tritium than the current AGR stations where the limits are 650 TBq y^{-1} while generating more electricity (1735 MWe for the UK EPR against up to 1261 MWe for an AGR). The calculated impact at 0.018 μSv y^{-1} is low.

560 As tritium production depends on power production rather than abatement techniques we consider that a quarterly notification level based on the maximum disposal (75 TBq y^{-1}) is appropriate in this case. We will take the stated maximum monthly estimate of 25 per cent of annual (18.75 TBq) and add two months at the ‘expected’ level of 13 TBq to give (rounded up) 45 TBq/quarter. This should highlight adverse trends in disposals and require an operator to demonstrate that BAT is still being applied if a QNL is exceeded.

9.3.2 Carbon-14

561 As described in chapter 7, 5-20 per cent of the carbon-14 produced (444 GBq y^{-1}) will be present in the aqueous or solid waste. (PCERsc6.3s6.3.1)

562 EDF and AREVA propose no specific techniques for carbon-14 reduction in aqueous waste from the UK EPR but have considered (EPRBs3.2):

a) decay by delayed discharge is not an option as the half-life of carbon-14 is 5710 years;

b) filters and demineralisers do remove some carbon-14 but this depends on the form of the carbon-14 and these items are optimised for corrosion products removal. Further treatment may be possible by filters and demineralisers but reductions are difficult to calculate and may only affect carbon-14 in inorganic forms while much may be organic. Further, increasing carbon-14 content on filter media and resins can give issues for solid waste disposal (current disposal facilities have a strict acceptance criterion for carbon-14). Further treatments by these techniques are not proposed;

c) evaporation of some aqueous effluent is carried out in the UK EPR. Evaporation of all aqueous effluent is possible but would require *'significant amounts of additional energy* [for example, 13 GWh to evaporate the 19000 m^3 of aqueous effluents from Flamanville units 1 and 2], *while conversion* [of the concentrate] *to solid waste would produce large volumes of solid waste*'. Further, past operational experience has shown that while much carbon-14 would be retained in concentrates, there is still significant carbon-14 activity in distillates and these must be discharged (in GDA to the sea). EDF and AREVA do not intend to perform additional evaporation for the UK EPR but offer no formal options assessment.

563 EDF and AREVA claim that while techniques have been used in the UK EPR to minimise the presence of carbon-14 in aqueous waste (see chapter 7.3.2 above), there are no techniques that are BAT for reducing the carbon-14 content of that waste.

564 **Our own assessment supported the EDF and AREVA claim. We conclude that, at this time, the UK EPR uses BAT to reduce the discharge of carbon-14 to the sea as there are no applicable reduction techniques available.**

565 The 'expected performance' value of 23 GBq y^{-1} was estimated from the basic source term of 444 GBq y^{-1} applying operational feedback experience from the predecessor 1300 MWe reactors. This is also about 5 per cent of the source term, so equates well to the expected distribution. (PCERsc6.3s6.3.2.1)

566 EDF and AREVA propose a 'maximum' value of 95 GBq y^{-1}. This is because:

a) the 444 GBq y^{-1} term was based on reactor availability of 91 per cent, and it is hoped the UK EPR will exceed this value;

b) the distribution of carbon-14 between gas and liquid in the UK EPR could be different to existing reactors, operational experience of an EPR is needed to confirm performance;

c) the 444 GBq y^{-1} source term assumed a coolant nitrogen content of 10 ppm (parts per million), if a higher content is found in operation then the nitrogen source term will increase.

567 We have limited information about discharges of carbon-14 to water from PWRs operating over the last 10 to 15 years, but we consider that the range of discharge to water of carbon-14 is 3 to 45 GBq y^{-1} for a 1000 MWe power station (see Annex 4). The 'expected performance' aqueous discharge of carbon-14 from UK EPR is 23 GBq (13.3 GBq normalised to 1000 MWe), well within this range. We conclude that aqueous discharge of carbon-14 from the UK EPR is comparable to other power stations across the world.

568 EDF and AREVA state that monthly discharges of carbon-14 are very dependent on power produced and generally unaffected by operating contingencies. However, operational management of aqueous discharges, as noted for tritium above, may

affect the level of discharge in any month. A 'maximum' monthly discharge of 24 GBq is proposed based on 25 per cent of the annual 'maximum'.

569 The radiological impact from the 'maximum' disposal of carbon-14 to the sea is stated as a dose to adults of 14 μSv y^{-1}, to children of 4.2 μSv y^{-1} and infants of 1.4 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables E, F and G.

570 We concluded above that the UK EPR uses BAT to minimise the aqueous discharge of carbon-14 with an 'expected performance' value of 23 GBq y^{-1}. While the level of headroom proposed is high, an additional 72 GBq y^{-1} to allow for the uncertainty of split between gas and liquid and level of nitrogen in the coolant, we do recognise the uncertainties at this time and will set an indicative annual disposal limit at 95 GBq, this gives a pessimistic impact assessment. We will review this limit at the earliest opportunity once operational experience is available.

571 We will set a quarterly notification level based on the 'expected performance' to give us an early indication if this performance cannot be met in operation. We have allowed for 25 per cent of annual discharge in one month (say 6 GBq) and average discharge (say 1.5 GBq) for two months. This gives a QNL of 9 GBq.

572 A respondent (GDA106) said that our QNL for carbon-14 appeared to be based on uniform discharge while operation would require several months arisings to be discharged in a single month. We followed information from EDF and AREVA as noted above to set our QNL and do not agree with this comment. As noted elsewhere in this document we may decide on two QNLs in future permits – one for 'normal' quarters and one for a quarter including shutdown.

9.3.3 Iodine radionuclides

573 As described above, iodine radionuclides are formed in the fuel and are only present in the coolant in the event of fuel cladding defects. Iodines tend to dissolve and are, therefore, mostly found in aqueous effluents. While it is not their main function, the demineralisers in the coolant purification system do absorb significant amounts of iodines. Also effluents are held up in tanks in the liquid waste processing system awaiting treatment or discharge, the delays will allow the shorter half-life iodine radionuclides to decay. (PCERsc6.3s6.4.1.1 and EPRBs3.6)

574 The EDF and AREVA BAT case for iodine radionuclides relies on:

a) improved fuel integrity;

b) removal in the demineralisers.

575 **Our assessment concluded that the very low levels of discharge and impact (see below) support the case that BAT is employed without more detailed assessment.**

576 The 'expected performance' is stated as 7 MBq y^{-1}. This is supported by operational feedback from predecessor reactors, but results of measurements are often below detection thresholds, so that the 7 MBq value is actually a 'limit of detection' value.

577 The 'maximum' value proposed is 50 MBq y^{-1}. This allows for some 40 MBq headroom over the 'expected value' and relates to operational experience of predecessor reactors when this value was achieved on rare occasions. The headroom allows for contingencies of fuel and treatment system failure. (PCERsc6.3s6.4.1.3)

578 We have limited information about the discharge to water of iodine radionuclides from PWRs operating over the last 10 to 15 years, but we consider that the range of

discharge to water of iodine radionuclides is 10 to 30 MBq y^{-1} for a 1000 MWe power station (see Annex 4). The ‘expected performance’ aqueous discharge of iodine radionuclides from UK EPR is 7 MBq (4 MBq normalised to 1000 MWe), below this range. We conclude that aqueous discharge of iodine radionuclides from the UK EPR is comparable to other power stations across the world.

579 Monthly discharges in normal operation are stated as being at detection threshold and equivalent to 0.7 MBq. However a worst-case scenario could see almost all the ‘maximum’ annual discharge in one month – the ‘maximum’ monthly discharge value is quoted as 50 MBq.

580 The radiological impact from the ‘maximum’ disposal of iodine radionuclides to the sea is stated as a dose to adults of 0.000076 μSv y^{-1}, to children of 0.000038 μSv y^{-1} and infants of 0.000022 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables E, F and G.

581 We concluded that BAT is used to minimise the discharge of iodine radionuclides to the sea with a ‘predicted performance’ of 7 MBq y^{-1}. We have decided that, at this level of discharge, and bearing in mind the very low impact, it is not proportionate to set a limit or quarterly notification level for the discharge of iodine radionuclides to the sea.

9.3.4 Other radionuclides

582 Aqueous waste can contain other radionuclides in addition to those specifically considered above. These are both suspended particulates and dissolved activated corrosion products (particularly cobalt-58 and cobalt-60) and fission products (particularly caesium-134 and caesium-137). (PCERsc6.3s6.4.2.1) The main source of these is the coolant. The coolant is recycled through filters and demineralisers in the chemical and volume control system (CVCS) where high decontamination factors are achieved (see chapter 8.3 above). EDF and AREVA say they rely on these systems for primary reduction of these other radionuclides. However, low concentrations are still found in managed discharges and minor leaks of coolant reaching the liquid waste processing system (LWPS).

583 PCERsc8.2s3.3.3 lists some available techniques to treat aqueous effluents:

a) chemical precipitation;

b) hydro-cyclone centrifuging;

c) cross-flow filtration;

d) ion exchange (demineralisation);

e) reverse osmosis;

f) evaporation.

584 PCERsc8.2s3.3.3.4 discusses some techniques being developed that could potentially be used to treat UK EPR effluents:

a) membrane technologies such as cross-flow, micro- and ultra-filtration might be used to retain particles down to 0.01 micron size;

b) reverse osmosis might be suitable to remove dissolved substances from effluent;

c) electrolysis might be used to remove electro-active materials such as corrosion products;

d) isotopic retention is an electrochemical process using a metallic catalyst that can reduce the concentration of some radionuclides.

585 EDF and AREVA claim that only the following techniques are BAT for use in the UK EPR:

a) filtration for removing particulate matter;

b) ion exchange systems for removing dissolved active materials;

c) evaporation for effluents which are incompatible with ion exchange resins, the concentrate is treated for disposal [as solid radioactive waste].

586 EDF and AREVA argue that other techniques are not currently developed for use in PWRs, while those chosen are in standard use. Further, the chosen techniques are adequate to optimise discharges.

587 **Our assessment concluded that, at this time, filtration by cartridge filter, ion exchange and, for effluents incompatible with ion exchange, evaporation are BAT for use in the UK EPR. However the operational management of the Liquid Waste Processing System (LWPS) will be critical to ensure that the impact of aqueous discharges on the environment will be minimised, see our assessment finding UK EPR-AF08 later in this section.**

588 A diagram of the LWPS is provided as Figure 5 in the IWSp37 and more detailed descriptions are in PCERsc6.2s1.1.3. Effluents are collected at the front end of the LWPS by tanks. Tank contents, depending on their analysis, may be treated by filtration, filtration and ion exchange and / or by evaporation. After treatment, the contents are pumped by way of a final filter to a set of discharge tanks.

589 In the UK EPR, single use cartridge filters are available to select as required by operations in the LWPS.: (PCERsc8.2s3.3.3.1)

a) floor drain system – 25 micron;

b) process drain system – 25 followed by 5 micron before demineraliser, 25 micron after (to remove any resin particles);

c) chemical drain system – 25 micron;

d) final filter before discharge tanks – 5 micron.

590 All filters are fitted with instruments to measure the pressure difference over the filter element. The pressure will increase as filters are used and retain particles. EDF and AREVA say that they will only change filter elements when a set pressure is exceeded. We confirm that this is BAT to minimise the volume of solid waste arisings from use of filters.

591 We raised a TQ on EDF and AREVA to provide a BAT case for the filter sizes chosen. The response to this TQ was after our consultation and provided information supported by EDF operational experience. A summary of this information is available in the latest revision of the PCER (PCERsc8.2s3.3.3.1).

592 The process drain system contains a demineralisation system with three beds which can be filled with (PCERsc8.2s3.3.3.2):

a) strong high-capacity anionic or macro-porous resins;

b) strong high-capacity gel-type cationic resins;

c) mixed-bed-type.

EDF and AREVA state that: '*The initial choice retained for the UK EPR is one high-capacity cationic bed and one mixed bed. The third space is left empty and is used if deemed necessary by the operator, for example if there is a problem with one of* *the beds (filling the third space will allow for maintenance to be carried out on the bed, without interruption of the filtering process); it also allows flexibility in dealing with specific pollutants (silver, tritium…), as it can be used for a specific treatment if necessary*.'

593 We raised a TQ on EDF and AREVA to provide a BAT case for the design of the demineralisation system. The response to this TQ was after our consultation and provided some additional information supported by EDF operational experience. A summary of this information is available in the latest revision of the PCER (PCERsc8.2s3.3.3.2).

594 The chemical drain system has an evaporator available. This separates chemically contaminated effluents into a distillate (only weakly active / polluted) and a concentrate containing most of the activity / contamination. The distillate is sent to the discharge tanks after monitoring. The concentrate is sent to the solid effluent treatment unit for treatment before disposal. We conclude that providing the evaporator on the UK EPR is BAT to treat otherwise untreatable aqueous waste.

595 **Our assessment of previous information and that supplied in response to our TQ concluded that, in principle, the liquid waste processing system (LWPS) equipment of the UK EPR contributes to BAT for minimising the discharge of fission and activation products.**

596 However, as the impact of other radionuclides is not insignificant, we require a demonstration that the LWPS uses BAT to minimise the discharge to sea of other radionuclides. The information provided by EDF and AREVA in response to TQ-EPR-1086 included a comparison of LWPS international best practice but indicated that final optimisation of the LWPS would need to be at the site-specific stage. EDF and AREVA said that decisions made by the operator will dictate the optimisation of the LWPS, for example when and whether the evaporator is used and optimal filter porosities and demineralisation media. We accept that operational management of the LWPS will affect discharges. We have therefore accepted in the above conclusion that equipment comprising the LWPS represents BAT but we will require future operators to demonstrate that their proposed management of the LWPS will also be BAT. This requirement is covered within assessment finding UK EPR-AF08 which follows in chapter 9.5.

597 EDF and AREVA claim that the 'expected performance' for discharge of other radionuclides (the total including cobalt-60 and caesium-137) is 0.6 GBq y^{-1}. This value is supported by operational data from predecessor reactors with an allowance for improvements in effluent treatment in the UK EPR. This value is without contingency allowances for such issues as start-up, shut-down, maintenance or leaking fuel. EDF and AREVA expect the UK EPR to discharge 10 per cent fewer other radionuclides than the predecessor 1300 MWe unit. (PCERsc6.3s6.4.2.2)

598 EDF and AREVA propose a 'maximum' annual disposal of 10 GBq. The headroom above 'expected performance' is not specifically quantified, but allows for contingencies such as fuel cladding defects combined with failure or unavailability of liquid treatment systems. (PCERsc6.3s6.4.2.3)

599 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to water of fission and activation products is 1 to 15 GBq y^{-1} for a 1000 MWe power station (see Annex 4). The 'expected performance' aqueous discharge of other radionuclides from UK EPR is 0.6 GBq (0.35 GBq normalised to 1000 MWe), well below this range. We conclude that the aqueous discharge of other radionuclides from the UK EPR is comparable to other power stations across the world.

600 EDF and AREVA say that monthly discharges are difficult to predict, as they depend on effluent management policy adopted and operational conditions. The monthly discharge during shutdown could be six times higher than other months. In normal operating conditions, monthly discharge could be up to 0.3 GBq. In extreme circumstances, the whole of the 'maximum' detailed above, 10 GBq, could be discharged in one month.

601 The radiological impact from the 'maximum' disposal of other radionuclides to the sea is stated as a dose to adults of 3.3 μSv y^{-1}, to children of 0.5 μSv y^{-1} and to infants of 0.06 μSv y^{-1}– from PCERsc11.1 Annex 3 Tables E, F and G. The greatest part of the dose is attributable to cobalt-60.

602 We concluded above that the UK EPR uses BAT to minimise the discharge to sea of other radionuclides with an 'expected performance' of 0.6 GBq y^{-1}. We set disposal limits based on BAT with minimum headroom to cover expected operational events. We believe that equipment failures should be rectified promptly and should not have a significant impact on annual discharges. We do not accept the EDF and AREVA proposal for 'maximum' annual disposal. We have considered past operational data and will allocate an additional 2 GBq y^{-1} above the 'expected performance' to allow for increased discharges due to fuel cladding defects or other contingencies. Our predicted maximum is, therefore, 2.6 GBq y^{-1}, and we will apply a x2 factor to set a disposal limit of 5 GBq y^{-1}. We wish to set limits separately for cobalt-60 and caesium-137, so will allocate the total 5 GBq as:

a) cobalt-60 – 1.5 GBq y^{-1};

b) caesium-137 – 0.5 GBq y^{-1};

c) other radionuclides not specifically limited – 3 GBq y^{-1}.

603 We wish to set a quarterly notification level based on the 'expected performance' to give us early indication if performance cannot be met in operation. We have allowed for 0.3 GBq in one month and average discharge for two months (say 0.05 GBq). This gives a QNL of 0.4 GBq for a total including cobalt-60 and caesium-137. We have apportioned this as follows:

a) cobalt-60 – 0.12 GBq;

b) caesium-137 – 0.04 GBq;

c) other radionuclides not specifically limited – 0.24 GBq.

9.4 Aqueous waste disposal to the environment

604 We have identified three effluent release points for the UK EPR (based on the reference plant, Flamanville 3) and allocated references as below (diagram PCERsc6.4s2.3 Figure 1 (page 84)):

a) W1 – combined discharge line from two sets of tanks:

   i) from the LRMDS tanks in the liquid radwaste monitoring and discharge system (LRMDS). These tanks collect effluent treated by the liquid waste processing system (LWPS).

   ii) from the ExLWDS tanks in the additional liquid waste discharge system (ExLWDS). These tanks are kept in reserve in case of issues with the LWPS or the LRMDS. The contents of these tanks can be sent back into the LWPS for treatment or discharged, as appropriate.

b) W2 – discharge line from the SiteLWDS tanks in the conventional island liquid waste discharge system (SiteLWDS). These tanks collect effluent from radiologically uncontrolled areas such as the turbine hall. In normal operation effluents collected by this system are uncontaminated but may show low levels of tritium in the event of any leaks from the primary to the secondary systems.

c) W3 – return line of circulating seawater cooling system. The seawater should be uncontaminated in normal operation. The seawater system serves various systems, each of which should have internal sample points for detection of contamination at point of return to the main system (PCERsc3.4s3.1.1):

   i) circulating water system to main condenser;

   ii) essential services water system;

   iii) service water circuit for conventional auxiliaries;

   iv) ultimate cooling system.

605 EDF and AREVA say that number and sizing of the LRMDS, ExLWDS and SiteLWDS tanks is a site-specific issue depending on number of reactors on a site and any discharge timing restrictions. At the Flamanville reference site there are 6 LRMDS, 3 ExLWDS and 4 SiteLWDS tanks (all of 750 m^3) that serve two existing 1300 MWe reactors, one EPR in construction and possibly another EPR in the future. We consider that the size of discharge tanks is an important BAT issue. We need to see that enough capacity is available not only to cope with normal operations but also to cope with foreseeable events such as equipment failures. We will not comment on tank sizes at GDA but will expect site-specific applications to provide a formal BAT case, justifying the number and volumes of discharge tanks proposed.

606 If we permit aqueous radioactive waste discharges from a UK EPR at the site-specific stage, our permit will allow discharge through points W1 and W2 under specific disposal limits and conditions. Discharges will not be continuous but on a tank by tank basis. When a tank needs to be discharged, its contents will be sampled and analysed. Data on the volume to be discharged and its radioactivity will be used within a management procedure to authorise the time and rate of discharge to ensure compliance with permit conditions. We will require the discharge lines to be fitted with MCERTS (our certification system for measuring equipment) flowmeters and flow proportional samplers at points W1 and W2 to provide permit compliance data. We mainly consider here the discharge of radioactivity but the sampling equipment may also be used for compliance purposes for other substances – see chapter 14.2.

607 The returning seawater should be uncontaminated. We will not require flow metering of this, flow will be directly related to pumps in service. We will not require continuous sampling as we consider risk of contamination is very low. However, we will require safe and permanent access to the return flow at point W3 for spot sampling to confirm no radioactive contamination or other contamination such as oil or chemicals.

608 An individual respondent (GDA38) asked that seawater be sampled regularly. Sampling of the returning seawater as well as environmental monitoring of the receiving sea will be conditions of our permit.

609 COMARE (GDA129) noted there was '*no mention of terminal filtration in sea discharge lines*, *which could be important in the event of waste processing plant failure*'. Filtration of the sea discharge would be difficult because of volumes involved and that the seawater will have considerable non-radioactive solids content. The system on the UK EPR involves collection of aqueous waste in

monitoring tanks before sampling and discharge. We expect systems to be in place to detect failure of processing plant such that the resulting waste would not be discharged, for example if high radioactivity was present. We believe additional final discharge filtration is not required. COMARE also mention continuous monitoring of the final discharge. We will require continuous monitoring of all waste streams entering the discharge pond and consider this adequate protection. Such arrangements exist at existing nuclear power stations.

610 The disposal route from points W1 and W2 is initially to join the high volume direct sea water cooling flow (67 $m^3 s^{-1}$) at the discharge pond. The combined flow is then sent to an outfall discharging some distance out from the shore. Once radioactive discharges have been minimised by other techniques, pre-dilution in a large flow before discharge to the environment is desirable to reduce initial concentrations before dispersion in the receiving waters.

611 We have not considered at GDA other site aqueous discharges such as surface water. The design of such systems will be site-specific and there should be no contamination in normal operation. We will review site drainage at site-specific permitting and, as a minimum, require accessible sampling points at final discharge locations for confirmation spot sampling.

612 For GDA, EDF and AREVA selected Irish Sea / Cumbrian waters for predicting dispersion of aqueous radioactive discharges using the model PC Cream. They said this would give pessimistic results for the dose impact calculations. The calculated total annual dose impact to the most exposed members of the public from ‘maximum’ discharges was 17 µSv for an adult, 4.7 µSv for a child and 1.5 µSv for an infant. Dose was largely due to eating seafood. The doses are low enough that we conclude that dispersion under GDA parameters is BAT.

613 The design and location of outfalls will be a highly site-specific issue. The operator for each specific site will need to demonstrate, by modelling, that the outfall proposed will be BAT for adequate dispersion in local waters.

614 West Somerset Council (GDA154) said that its primary concern was ‘*that site-specific proposals are assessed based on detailed modelling of site-specific conditions to provide confidence that the integrity of marine waters would not be compromised and that human and vulnerable marine receptors (such as those which contribute to the qualification of Natura 2000 sites) would not be affected*’. We confirm that this will need to be the outcome of the modelling we require before a permit could be issued.

615 There were queries at our stakeholder seminar about discharge to an estuary. EDF and AREVA defined their generic site as having discharge to the open sea only and so this document only considers this option. If a future operator wished to discharge to an estuary then some aspects of GDA covered in this chapter would not apply and a full case for the discharge would need to be made to us, including a review of BAT for minimising aqueous radioactivity.

9.5 The Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR)

616 Several respondents (GDA82, 95, 133, 149 and 153) as well as attendees at our stakeholder seminar raised the topic of compliance with the UK’s obligations under OSPAR. In particular the use of evaporation to treat aqueous radioactive waste was suggested. We have included in this section a summary of OSPAR, relevant information, and our conclusions on this matter.

617 The UK is a Contracting Party to the OSPAR Convention and the Government has published its 'UK Strategy for Radioactive Discharges' (DECC, 2009b) which sets out a framework for implementing the UK's obligations in respect of the OSPAR Radioactive Substances Strategy[10]. The outcomes expected of the UK Strategy will be:

a) progressive and substantial reductions in radioactive discharges;

b) progressive reductions in concentrations of radionuclides in the marine environment resulting from radioactive discharges, such that by 2020 they add close to zero to historic levels;

c) progressive reductions in human exposures to ionising radiation resulting from radioactive discharges, as a result of planned reductions in discharges.

618 The OSPAR Convention also includes the requirement for Contracting Parties to use Best Available Techniques (BAT) to minimise discharges of radioactivity to the marine environment. The Government gave us guidance in 2009 to base our regulation of radioactive discharges on the use of BAT and highlighted the importance of BAT in the optimisation of doses and the setting of discharge limits (DECC, 2009a). We anticipated the requirement to use BAT and throughout GDA required EDF and AREVA to demonstrate that the UK EPR uses BAT from the initial generation of radioactivity (see our chapter 7) to final discharge. We consider our approach to GDA contributes significantly to the outcomes of the UK Strategy noted above.

619 This document has set out our conclusions that the UK EPR design incorporates equipment that is BAT to minimise discharges of radioactivity to the sea. This shows compliance with part of the UK obligations under OSPAR. The UK EPR design includes an evaporator capable of treating certain aqueous radioactive waste streams. The GDA operational proposal is to only treat aqueous wastes incompatible with ion exchange (design basis 3000 m^3 y^{-1}) but the evaporator has the capacity to process substantially more aqueous waste. Future operators will be responsible for the aqueous waste management and decisions on quantities to be evaporated. Future operators will also be responsible for choosing the optimal filter porosities and demineralisation media. We have therefore decided to add an assessment finding on this topic:

a) Future operators shall, during the detailed design phase, provide their proposals for the operational management of the Liquid Waste Processing System to minimise the discharge of radioactivity from the site so that exposures of any member of the public and the population as a whole are kept as low as reasonably achievable (ALARA) and to protect the environment. The proposals should be supported by a BAT assessment to show that the use of the evaporator, the choice of filter porosity and the demineralisation media have been optimised to minimise the dose to members of the public. The future operator shall also provide evidence that the Water Treatment Systems have sufficient capacity and resilience to cope with all the aqueous radioactive waste arisings consigned to the evaporator by the proposals. The proposals should consider all plant states, including for example outages and unavailability due to maintenance or breakdown. (UK EPR-AF08)

620 The impact of radioactive discharges to the marine environment from the UK EPR design will be less than the currently operating nuclear power plants in the UK, and as these are replaced we anticipate a reduction in the total UK discharges.

[10] Ministerial Meeting of the OSPAR Commission, Summary Record OSPAR 98/14/1-E, Annex 35.

621 We note that EDF and AREVA predict discharges of carbon-14 from the UK EPR that will be higher than the existing PWR at Sizewell. For example, Sizewell B reported an estimated discharge of 3.3 GBq in 2008 (2.7 GBq normalised to 1000 MWe) whilst the predicted annual discharge from a UK EPR is 23 GBq (13.3 GBq normalised to 1000 MWe.

622 Carbon-14 is a naturally occurring radionuclide, global annual production of natural carbon-14 is around 1000 TBq, and present in the sea at levels up to 5 Bq m^{-3}. While discharges to sea from a UK EPR could achieve 50 Bq m^{-3} carbon-14 at the point of discharge this will be rapidly dispersed and is unlikely to affect the background concentration beyond a few hundred metres.

623 **We conclude that the discharge of carbon-14 from a UK EPR will not conflict with the OSPAR aim of achieving concentrations in the environment near background values for naturally occurring radioactive substances**.

624 We do not have information on the effect of evaporation on carbon-14 contained within the aqueous wastes treated. The carbon-14 will be distributed mainly between the concentrate (which will become solid waste after treatment) and the distillate (which will be discharged to sea) while gaseous forms of carbon-14 will separate out and be discharged to the air through the Gaseous Waste Processing System. We will need the future operators to tell us how their proposed management of aqueous wastes will affect the distribution of carbon-14 over all discharge routes. We have therefore included an assessment finding:

a) Future operators shall provide a predicted mass balance during the detailed design stage showing how their proposed aqueous radioactive waste management regime will affect the disposal of carbon-14 to the gaseous, solid or aqueous routes. For each route the form of carbon-14 expected shall be provided. For solid wastes the quantities of each type of waste shall be provided with expected carbon-14 content. (UK EPR-AF09)

625 We have set out our assessment of the impact of radioactive discharges to the sea from the UK EPR in chapter 13 of this document. We conclude that doses to the public (28 µSv y^{-1}) from the UK EPR will be as low as reasonable achievable for the generic site. Future operators will need to confirm that assessment for each specific site proposed for a new nuclear power plant.

10 Solid radioactive waste

10.1 Conclusions

626 Our conclusions are unchanged since our consultation, however, we have reworded our assessment findings and added two additional findings on specific techniques for minimising LLW and ILW, and incineration of ILW.

627 **We conclude that:**

a) **EDF and AREVA have identified all low level waste (LLW) and intermediate level waste (ILW) waste streams that a UK EPR will typically produce.**

b) **The UK EPR uses BAT to minimise the arisings of LLW and ILW, subject to assessment finding UK EPR-AF11.**

c) **The UK EPR uses BAT to treat and condition LLW and ILW prior to disposal, subject to assessment finding UK EPR-AF12.**

d) **The UK EPR is not expected to produce LLW or ILW for which there is no foreseeable disposal route.**

e) **EDF and AREVA have provided valid estimates for the annual arisings (during operations and decommissioning) of LLW and ILW. These arisings (during operations) are consistent with those of comparable reactors around the world (Isukul, 2009).**

628 As part of our assessment, we identified the following assessment findings:

a) The future operator shall provide confidence that adequate radioactive waste management cases (RWMCs), supported by appropriate stage Letters of Compliance (LoCs), can be developed for all intermediate level waste (ILW) on the timescales identified in EDF and AREVA's plan for disposability of ILW. (UK EPR-AF10)

b) The future operator shall provide evidence during the detailed design phase that the proposed specific techniques for preventing and, where that is not possible, minimising the creation of low level waste (LLW) and intermediate level waste (ILW) are the best available techniques (BAT). (UK EPR-AF11). Prior to consultation we only proposed an assessment finding relating to the disposal of LLW and ILW (UK EPR-AF12, below).

c) The future operator shall provide evidence during the detailed design phase that the proposed specific techniques for treating and conditioning of low level waste (LLW) and intermediate level waste (ILW) before disposal are the best available techniques (BAT). (UK EPR-AF12)

d) If smelting of any low level waste (LLW) is pursued, the future operator shall demonstrate that the conditions of acceptance of the selected smelting facility can be met. (UK EPR-AF13)

e) If incineration of any low level waste (LLW) is pursued, the future operator shall demonstrate that the conditions of acceptance of the selected incineration facility can be met. (UK EPR-AF14)

f) If incineration of any intermediate level waste (ILW) is pursued, the future operator shall demonstrate that the conditions of acceptance of the selected incineration facility can be met. (UK EPR-AF15)

10.2 Background

629 In their submission, EDF and AREVA describe how low level waste (LLW) and intermediate level waste (ILW) will be generated, managed and disposed of throughout the facility's lifecycle. EDF and AREVA have also provided basic evidence of how they will minimise the quantities of LLW and ILW needing disposal. This includes appropriate characterisation and segregation. We have assessed the information provided as detailed in chapter 7 and below, and our conclusions on LLW and ILW are stated above. We accept that LLW and ILW will be treated and conditioned using proven and recognised techniques.

630 A number of consultation responses were received in regard to solid radioactive waste which are discussed in the relevant parts of this chapter. Questions on solid radioactive waste were also raised at our 6 July 2010 GDA stakeholder seminar and these are also considered in this chapter.

10.3 Creation of solid waste

631 EDF and AREVA identify and quantify the solid radioactive waste that will arise during the operational phase (PCERsc3.3). They state that solid radioactive waste resulting from normal operation (including maintenance) arises either in the nuclear island or in the waste treatment building (ETB). They say that the UK EPR will produce three types of solid radioactive waste (PCERsc6.2):

a) waste known as 'process' waste, associated with generating power. This results from treating fluids, in order:

   i) to limit the contamination and reduce its activity, so that workers are not exposed to radiation;

   ii) to reduce the activity of discharged effluent, whether aqueous or gaseous.

   The process waste from treating gaseous effluent is made up of mainly filters and iodine traps. From aqueous waste treatment, the process waste consists of filters, concentrates and ion-exchange resins.

b) dry active waste from maintenance work (mending faults, repairs, replacement of radioactive equipment, etc.). It comprises mainly of compactable materials, such as vinyl, gloves, adhesive tape, papers, trunking for exhaust fans, etc.

c) other waste, generally from so called sundry incidents (for example, contaminated oils).

632 Additionally, during the operation of the UK EPR, some core components used to control or measure neutron activity may need to be replaced during outages. These include neutron absorber rods and rod cluster control assemblies.

633 In the PCER and supporting documentation, the types of solid radioactive waste are described as shown in the table below:

	Types of waste
Process waste	Ion-exchange resins from the nuclear island
	Low activity steam generator blow down system (SGBS) ion-exchange resins (without regeneration)
	Wet sludges (sumps, tanks)
	Water filters from effluent treatment
	Evaporator concentrates
	Air and water filters
Operational waste	Pre-compacted and non compactable dry active waste (DAW)
	Oils (and solvents)
	Scraps
	Other operational waste

634 EDF and AREVA state that the volume of solid radioactive waste depends on the balance between environmental discharges and packaged waste generation in managing the installation and may therefore change according to the various effluent treatment methods. PCERsc3.3 Table 2 and PCERsc6.3 Table 1 provide, by volume, the annual estimated production of raw waste (before conditioning) for each type of waste for one UK EPR unit. PCERsc6.3 Table 5 gives the distribution of LLW and ILW in terms of volume of packages to be disposed of or stored per year. This shows that the volume of conditioned LLW to be disposed of per year is 24.5m^3, which, assuming the UK EPR design is for a single, pressurised water reactor (PWR) capable of generating in total 1735 MWe of electricity, is equivalent to 14.1m^3 per 1000 MWe plant-year of operation. This table also shows that the volume of conditioned ILW produced per year is 46.2 m^3, which is equivalent to 26.6m^3 per 1000 MWe plant-year of operation.

635 Further information is given in PCERsc6.3. This includes the characteristics of the reference case packaged wastes. Additionally, waste stream datasheets for ion exchange resins, spent filters, dry active waste, tank sludges, evaporator concentrates, low activity resins, air and water filters, oils and metal maintenance waste are given in EDF and AREVA's solid radioactive waste strategy report (SRWSR). These list data on waste origin, waste physical description, nature of radioactive material, annual arising, total arising, waste classification at time of generation, main radionuclides and hazardous substances.

636 EDF and AREVA have estimated the volume of solid radioactive decommissioning waste to be expected after a designed service life of 60 years. An estimated volume of conditioned LLW and very low level waste (VLLW) from decommissioning is around 25,000m^3 (PCERsc5.2s4.4). The waste is from the following sources:

a) primary circuit;

b) nuclear steam supply system equipment;

c) balance of nuclear island (BNI) equipment;

d) concrete due to clean up of BNI.

637 Estimated volumes of ILW from decommissioning are given in PCER chapter 5 and the SRWSR. Contaminated ILW, which consists of ion-exchange resins used during the full decontamination of the primary circuit, amounts to around 30 to 40 m^3. Activated ILW consisting of metallic and concrete waste from the dismantling of the activated components near the reactor core amount to approximately 450 te of raw solid metallic waste and 180 te of concrete. An estimated volume of conditioned ILW from decommissioning is around 1400m^3 (PCERsc5.2s4.4). The ILW waste is from the following sources:

a) primary circuit;

b) decontamination.

638 The estimates for operational waste in EDF and AREVA's submission for the volumes of operational LLW and ILW appear to be reasonable for the UK EPR. These estimates were derived by EDF and AREVA using 15 years worth of waste arisings data from across the whole French fleet. The estimates used data from the EDF tracking system which records the characteristics of every solid waste package produced on the 19 sites in France. (PCERsc6.3s3.1)

639 The Health Protection Agency (HPA) (GDA88) provided the following response to our consultation: '*The consultation document should make it clear in its conclusions that AREVA and EDF's 'reference case', Flamanville 3, is still under construction and will not be operational for at least 2 years and therefore cannot provide evidence of actual waste arisings*.' As stated above, the estimates for operational waste were derived by EDF and AREVA using 15 years worth of waste arisings data from across the whole French fleet. We consider these estimates to be reasonable.

640 Additionally, the HPA (GDA88) commented that the reference on the review of waste arisings at comparable reactors (Isukul, 2009) is not available in the public domain, and therefore it is difficult to compare EDF and AREVA's estimates with independently collated data. We can confirm that this reference is available through the Imperial College London library service.

641 The Committee on Medical Aspects of Radiation in the Environment (GDA129) commented that more emphasis should be placed on re-use, recycling and decontamination of waste on reaching authorisation limits, particularly for solid waste. We have not set any limits on solid radioactive waste in GDA, and we no longer set specific limits in permitting, relying on the principle that waste should be minimised at source. We agree that EDF and AREVA have only provided basic evidence of how they will minimise the quantities of LLW and ILW needing disposal. Hence, we require evidence during the detailed design phase that the proposed specific techniques for preventing and, where that is not possible, minimising the creation of LLW and ILW are BAT (UK EPR-AF11). We also require evidence during the detailed design phase that the proposed specific techniques for treating and conditioning of LLW and ILW before disposal are BAT (UK EPR-AF12).

10.4 Management and disposal of low level waste

642 In this section we cover our assessment of the management and disposal of LLW. LLW is defined in the UK as 'solid radioactive waste having a radioactive content not exceeding 4 GBq per tonne (GBq te^{-1}) of alpha or 12 GBq te^{-1} of beta / gamma activity', but we also consider here some liquid waste such as contaminated oils. These types of low level waste are usually suitable for disposal at the low level

waste repository (LLWR) near Drigg, disposal by on or off-site incineration, or transfer off-site for recovery (for example, of metals).

643 Having minimised the overall production of radioactive waste, the application of BAT to minimise the activity in gaseous and aqueous discharges tends to transfer activity to low (and intermediate – see below) level solid waste. This is in line with the principle of preferred use of ‘concentrate and contain’ over ‘dilute and disperse’ (DECC, 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 volume of LLW 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.

644 We summarise below the information presented in EDF and AREVA’s submission on the management and disposal of LLW. We assessed all this information and used the GDA process of ROs and TQs to query and expand information where necessary. The conclusions of our assessment are provided at the end of this sub-section.

645 EDF and AREVA state in PCERsc6.2 that solid radioactive waste is segregated at source in each area as it arises, both in terms of activity and its chemical and physical characteristics (for example, combustible, compactable and non-combustible / non-compactable). Activity assessment is determined by measuring with handheld monitors and applying a nuclide fingerprint applicable for the source.

646 For the reference case, the treatment of operational LLW and ILW will be carried out by two solid radioactive waste treatment systems; the TES unit system located in the EPR nuclear auxiliary building (NAB) and the 8TES system located in the UK EPR waste treatment building (ETB). The 8TES system will comprise of effluent storage facilities for the resins and evaporator concentrates and conditioning facilities for the raw solid radioactive waste from the nuclear island and the ETB that results from normal operation. The TES unit system will handle the filter replacement and the transfer of resins from the NAB to the ETB. A filter handling machine will remove the used filters and place them in a concrete enclosure. Spent resins will be pumped to the 8TES storage tanks of the ETB by the 8TES system. EDF and AREVA propose that resins, filter contents, and other ILW will be encapsulated in concrete containers. There will be an installation in the ETB for compacting low-activity operational waste. All conditioned waste will then be kept on site for interim storage before being sent off-site to a final disposal location or to a treatment plant for additional processing (for example, incineration, smelting etc). The treatments, conditioning and packaging of operational solid radioactive waste is presented in PCERsc6.3 Table 3 and detailed in PCERsc6.4. EDF and AREVA provide further information on other potential waste management arrangements in the ETB in the SRWSR to accommodate different operators.

647 In response to additional queries raised by ONR as part of its Step 4 assessment on conditioning of waste produced by the UK EPR, EDF and AREVA provided further information in December 2010. This included more information on the management of radioactive oils and sludges, and the ETB. This information is in the radioactive waste conditioning report (see Schedule 1 of Annex 1).

648 The following packaging will be used for LLW:

a) metallic drum 200 litres: These drums will mainly be used for the packaging of LLW to be shipped directly to the LLWR;

b) plastic drum 200 litres: These drums have been developed specifically for the incineration process and they are directly introduced to the furnace;

c) metallic boxes 1 m^3: These boxes will be used to collect and ship metallic waste and cut scraps for melting.

649 The storage capacity of the reference ETB is enough to ensure buffer storage of LLW for more than one year of operating, including maintenance operations, even in the case that two UK EPR units share the ETB. (PCERsc6.4s4.2.4.1.5).

650 EDF and AREVA state in PCERsc6.5 and in the SRWSR that during the timescale for disposal of ILW to a disposal facility, it is possible that some waste may decay below the ILW threshold limits. Although initially stored as ILW, these waste streams can be re-categorised, removed from the interim storage facility and shipped as LLW. The Health Protection Agency (GDA88) responded to our consultation saying that is not clear if as a result of this reclassification, or for other reasons, repackaging is likely to be required and what provisions have been made if this is the case. EDF and AREVA do not provide details of this in their submission. This is a matter that we will assess at the site-specific permitting stage.

651 Disposability of operational LLW is discussed in PCERsc6.5 of the PCER. EDF and AREVA will dispose of LLW promptly after it has been generated to the low level waste repository (LLWR). EDF and AREVA have completed LLWR form D1s (Request for agreement in principle to dispose of radioactive waste at the low level waste repository) for each of the UK EPR LLW streams (except waste oils). These forms describe the nature of the process producing the waste, the type of radioactive waste generated and the physical and chemical form of the waste and its radiological characteristics.

652 Although D1 forms have been completed for all UK EPR operational LLW (except waste oils), EDF and AREVA have identified waste streams that are likely to be suitable for incineration and smelting to minimise the waste sent to the LLWR. We note that we would need a BAT assessment to consider other options. We have an assessment finding on this (UK EPR-AF12).

653 EDF and AREVA have provided us with signed form D1s from the LLWR, giving agreement in principle for the treatment / disposal of the following LLW:

a) ion exchange resin;

b) ion exchange beads;

c) spent filter cartridges;

d) air filters and water filters;

e) maintenance and operational very low level waste;

f) stainless steel waste;

g) maintenance and operational low level waste;

h) sludges;

i) concentrates.

654 The LLWR recognises that EDF and AREVA's form D1 applications represent assumed waste disposals at some point in the future and, as such, it cannot guarantee future capacity today. However, the LLWR has assessed EDF and AREVA's application against their current arrangements and can give agreement in principle on the basis that this waste would be suitable for treatment / disposal against their current arrangements.

655 EDF and AREVA state that contaminated waste oils and oily, solvent or greasy rags produced by maintenance will be incinerated. They provide evidence that this

waste will meet the conditions for acceptance at the Centraco facility in France. They also provide confidence that these types of waste would be accepted at the Tradebe incinerator in the UK. (PCERsc6.2s3.4.1.2)

656 Smelting is also considered for LLW metals as described in PCERsc6.3. However, EDF and AREVA have not carried out a review of this waste stream against the conditions of acceptance of a smelting facility to show that they can be met. This is therefore the subject of assessment finding UK EPR-AF13.

657 Incineration is also considered for SGBS ion-exchange resins (without regeneration), evaporator concentrates, pre-compacted operational waste and operational waste as mentioned in PCERsc6.3. However, EDF and AREVA have not carried out a review of these waste streams against the conditions of acceptance of an incineration facility to show that they can be met. Therefore, this is the subject of assessment finding UK EPR-AF14.

658 EDF and AREVA have considered the treatment and disposal of large, one-off solid radioactive waste items that could need replacing during the operation of the UK EPR. They consider steam generators and reactor pressure vessel heads. EDF and AREVA state that these items will be LLW and that one method of treatment and disposal will be to cut them into pieces, place pieces in containers and send containers for disposal at the LLWR. (PCERsc6.3s3.2.6)

659 EDF and AREVA expect decommissioning waste will produce similar waste types as the operational phase and, therefore, assume it will be compliant with the LLWR acceptance criteria. The SRWSR assumes that the LLW produced during the dismantling of a reactor is conditioned by packing in half height ISO (HHISO) containers. EDF and AREVA provided a document detailing their decommissioning waste inventory evaluation (ELIDC0801302A).

660 EDF and AREVA state in PCERsc6.3 that they currently envisage reducing the sources of solid waste volume compared with the existing plants' feedback as follows:

a) designation at the design stage of clean-waste zoning, enabling sorting of waste at source and segregating of conventional waste from non-contaminating work in the restricted area;

b) better control of source term through carefully selecting materials in contact with the primary coolant, which then leads to reduced production of corrosion products (a reduction in cobalt 60 activity in particular);

c) optimisation of the chemical treatment of primary coolant;

d) a greater surface area on the chemical and volume control system (CVCS) purification filters than on the 1300 MWe and N4 units (predecessor to the UK EPR), through using multi-cartridge baskets and not single cartridge.

We consider this to be good practice.

661 EDF and AREVA state that it should be noted that the volume of solid waste depends on the balance between environmental discharges and packaged waste generation in managing the installation, and may, therefore, change according to the various effluent treatment methods.

662 EDF and AREVA state in PCERsc6.5 that in order to minimise the inventory of waste consigned to LLWR, where the characteristics of LLW streams or packages are such that they could be treated as VLLW, LLWR have confirmed that they will offer services to dispose of such waste.

663 EDF and AREVA state in PCERsc8.2 that an 'EPR environment' design review took place in October 2004. One recommendation from this was to reduce the volume

of solid waste, in particular by optimising the room zoning and a detailed analysis of the operating procedures and waste inventory of the existing units. They claim that they will reduce the volume of solid waste by ensuring waste is segregated as it is generated, mainly during maintenance operations in the nuclear buildings. (PCERsc8.2s2.3) We accept this review finding. The Committee on Medical Aspects of Radiation in the Environment (GDA129) commented that they commend this approach aimed at minimising solid waste production.

664 In PCERsc8.2, EDF and AREVA describe how they consider that BAT has been applied to each significant waste stream. EDF and AREVA state in their BAT demonstration report (EPRB) that BAT is being applied in the design of the UK EPR to minimise radioactive waste at source and to minimise the impacts of the disposal of waste into the environment. Having reviewed this information, we accept that the UK EPR uses BAT to minimise the arisings of LLW subject to assessment finding UK EPR-AF11.

665 The SRWSR states that the UK EPR design will enable decommissioning to be performed to minimise radiation doses to workers and minimise the amount of radioactive waste generated. The SRWSR discusses the following features that have been incorporated into the design:

a) choice of materials of construction to minimise activation;

b) optimisation of neutron shielding;

c) optimisation of access routes to nuclear areas;

d) reactor systems design;

e) ease of removal of major process components;

f) submerged disassembly of reactor pressure vessel;

g) modular thermal insulation;

h) fuel cladding integrity;

i) design for decontamination;

j) prevention of contamination spread;

k) minimisation of hazardous materials.

666 EDF and AREVA state that improvements and provision are included in the UK EPR design based on feedback experience, in order to avoid replacing during the UK EPR's 60 years of operation large one-off items such as reactor pressure vessel heads and steam generators. They also state that good chemistry management during operation should prevent the build up of crud and activity due to contamination in the steam generators over the operating life. (PCERsc6.3s3.2.6)

667 Ingleby Barwick Town Council (GDA38) provided the following response to our consultation: '*This needs much more detail to give the public reassurance and to prevent misinformation from the anti-nuclear lobby. Need to reduce Cobalt 60 as it is a corrosive product. Need strict supervision of waste. Keep waste separate to reduce contamination of LLW.*' We agree that waste should be minimised. We require evidence during the detailed design phase that the proposed specific techniques for preventing and, where that is not possible, minimising the creation of LLW and ILW are BAT. We also require evidence during the detailed design phase that the proposed specific techniques for treating and conditioning of LLW and ILW before disposal are BAT. These are assessment findings in our conclusions on solid radioactive waste (UK EPR-AF11 and UK EPR-AF12). Subject to these assessment findings, we are satisfied that the UK EPR uses BAT to minimise the

arisings of LLW and ILW and uses BAT to treat and condition LLW and ILW prior to disposal.

668 Maldon Town Council (GDA51) provided the following response: '*Solid radioactive waste treatment as proposed not up to spec of Magnox South e.g., Bradwell. We see no need for local incineration, transport by rail a better option for eventual disposal. UK EPR we note your sceptical comments. Also that on site smelting has been considered, as has incineration, but not carried out a review of waste streams. Just implied that other plants around the world are worse. Only basic evidence provided'*. We do not expect the information on solid radioactive waste treatment to have the same level of detail as that of an existing plant or one that is undergoing decommissioning. We agree that EDF and AREVA have only provided basic evidence of how they will minimise the quantities of LLW and ILW needing disposal. Hence, we require evidence during the detailed design phase that the proposed specific techniques for preventing and, where that is not possible, minimising the creation of LLW and ILW are BAT (UK EPR-AF11). We also require evidence during the detailed design phase that the proposed specific techniques for treating and conditioning of LLW and ILW before disposal are BAT (UK EPR-AF12). We also have assessment findings that if smelting or incineration of LLW is pursued, the future operator shall demonstrate that the conditions of acceptance of the selected smelting / incineration facility can be met (UK EPR-AF13 and UK EPR-14).

669 Several respondents, including the Nuclear Legacy Advisory Forum (NuLEAF) (GDA80), Somerset County Council (GDA161), Cumbria County Council (GDA166), West Somerset Council and Sedgemoor District Council (GDA154), and Suffolk County Council (GDA72) thought that we were being overly optimistic in our conclusions on LLW because of the amount of space available for disposal at the LLWR, the time it would take to site any replacement LLW disposal facilities and the extent that landfills will become available for the disposal of VLLW. Additionally, at our stakeholder seminar, the following four questions / comments were raised: '*The adequacy and responsibility for the existing low level waste storage (off site)? What is the NDA's responsibility? What is the capacity and suitability of storage space for the new build? Concerns due to lack of planned waste storage facility.*' This is outside the scope of GDA because under the Energy Act 2004, the NDA has the responsibility for developing a UK-wide strategy for managing the UK nuclear industry's LLW.

670 Suffolk Coastal District Council (GDA165) responded to our consultation stating that it supports the response from NuLeaf (GDA80), dated 4 October 2010, given that the Council is a member of NuLeaf and has in the past expressed concerns about the arrangements for nuclear waste storage / disposal. We have addressed the response from NuLeaf in several chapters within this decision document.

671 NNB Genco (GDA106) provided the following response to our consultation: '*We welcome the Environment Agency's conclusions on solid radioactive waste, that all waste streams have been identified and that proven and recognised treatment and conditioning techniques will be used. We agree that the design is not expected to produce Low Level Waste (LLW) for which there is no foreseeable disposal route. We recognise that prospective operators, including NNB GenCo, will need to demonstrate that site-specific strategies for waste management represent BAT. NNB GenCo will work to implement an Integrated Waste Strategy, informed by the Waste Hierarchy, which optimises treatment methods and disposal routes in step with development of the UK LLW strategy*.'

672 Horizon Nuclear Power (GDA127) provided the following response with respect to the issues raised in our consultation document on LLW:

a) *'Meeting the conditions of acceptance for smelting of LLW during site-specific permitting: Horizon is rather surprised that this issue was raised specifically. It is clear that if we wish to pursue smelting of LLW as part of a recycle, reuse and waste minimisation strategy, then we would need to identify an appropriate service provider and discuss with them whether our waste could be handled by their facility.'*

b) *'Meeting the conditions of acceptance for incineration of waste during site-specific permitting: Horizon is rather surprised that this issue was raised specifically. It is clear that if we wish to pursue incineration of waste as a waste minimisation strategy, then we would need to identify an appropriate service provider and discuss with them whether our waste could be handled by their facility.'*

c) *'Evidence during site-specific permitting that specific arrangements for minimising the disposals of LLW and ILW are BAT: Horizon is aware that during site-specific permitting it will need to present information to demonstrate BAT. Minimising the disposals of LLW and ILW is intimately linked with how the reactor is operated, what discharge abatement technology is deployed and what conditioning and packaging technologies are used. Minimising the quantities of waste for disposal is not something that can be targeted in isolation but will instead be a balance between a number of competing issues such as operator doses and environmental discharges*.'

673 We have raised the smelting and incineration of waste as assessment findings because the estimates for the volumes of LLW in EDF and AREVA's submission are based on the assumption that some will be smelted or incinerated. We understand that if this is not the case then the volumes will be higher than that estimated. We note that EDF and AREVA have provided us with approved form D1s from the LLWR, giving agreement in principle for the treatment / disposal of the waste in this category. We agree that operators should use BAT to achieve a high degree of protection of the environment, taken as a whole and to meet the principle of optimisation.

674 West Somerset Council and Sedgemoor District Council (GDA154) made the following point in response to our consultation: '*The techniques and processes described generally appear satisfactory; however several of these, for example metal smelting and incineration, rely on the establishment and development of suitable supply chains to ensure that they can play an effective role in waste minimisation. Where these do not exist, the burden of waste management will fall entirely on disposal to GDF and LLWR*.' We note this comment but this is outside the scope of GDA. We also note that incineration and metal recycling facilities are now available.

675 Studsvik UK Ltd (GDA131) provided the following response: *'BAT needs to be applied to the waste treatment as well. It is not clear how BAT or the Waste Management Hierarchy has been considered for all solid radioactive wastes. Treatment of metallic waste has been considered, but no facilities have been investigated or if the potential waste will fit their waste acceptance criteria (WACs). Incineration of LLW has been checked against the WACs for one facility, Centraco, partly owned by EDF and one VLLW facility in the UK'.* We agree that EDF and AREVA have only provided basic evidence of how they will minimise the quantities of LLW and ILW needing disposal. Our assessment findings UK EPR-AF11 and UK EPR-AF12 address this. Assessment findings UK EPR-AF13 and UK EPR-AF14 address the WAC comment.

676 Several respondents, including; individual respondents (GDA25, GDA84), the Nuclear Technology Subject Group of the Institution of Chemical Engineers

(GDA67),Springfields Site Stakeholder Group (GDA96), Horizon Nuclear Power (GDA127) and the Institution of Mechanical Engineers (GDA145) said that they were satisfied with our conclusions on solid radioactive waste.

677 **We conclude that:**

a) **EDF and AREVA have identified all LLW waste streams that a UK EPR will typically produce.**

b) **The UK EPR uses BAT to minimise the arisings of LLW, subject to assessment finding UK EPR-AF11.**

c) **The UK EPR uses BAT to treat and condition LLW prior to disposal, subject to assessment finding UK EPR-AF12.**

d) **The UK EPR is not expected to produce LLW for which there is no foreseeable disposal route. EDF and AREVA have demonstrated that the waste streams would meet the criteria for disposal in a LLW facility.**

e) **EDF and AREVA have provided valid estimates for the annual arisings (during operations and decommissioning) of LLW. These arisings (during operations) are consistent with those of comparable reactors around the world (Isukul, 2009). The arisings of LLW are below the European Utility Requirement (European Utility Requirements for LWR Nuclear Power Plants Rev C Apr 2001 (Volume 2 chapter 2, section 5.2)) objective of less than 50 m^3 per 1000 MWe plant-year of operation.**

10.5 Management and disposal of intermediate level waste

678 In this section we cover our assessment of the management of ILW. ILW is waste with activity levels exceeding the upper boundaries for LLW, but which does not require heat generation to be accounted for in the design of disposal or storage facilities. There are currently no final disposal facilities for ILW in the UK. However, the Government has stated (BERR, 2008a) that it is satisfied that:

a) a geological disposal facility would provide a possible and desirable mechanism for disposing of higher level waste (both from a new nuclear programme and existing legacy waste);

b) there are feasible and long-term mechanisms through the Managing Radioactive Waste Safely (MRWS) (Defra et al 2008) programme for identifying a suitable site and for constructing a geological disposal facility.

679 Although a permit for final disposal may not be required for a considerable time, we expect EDF and AREVA to show now whether the waste:

a) Is likely to be suitable for disposal in a geological repository;

b) will be appropriately managed in the interim, so as not to prejudice its ultimate disposal.

680 We summarise below the information presented in EDF and AREVA's submission on the management and disposal of ILW. We assessed all this information and used the GDA process of ROs and TQs to query and expand information where necessary. The conclusions of our assessment are provided at the end of this sub-section.

681 EDF and AREVA state in PCERsc6.2 that solid radioactive waste is segregated at source in each area as it arises, both in terms of activity and its chemical and

physical characteristics (such as combustible, compactable and non-combustible / non-compactable).

682 For the reference case, the treatment of operational LLW and ILW will be carried out by two solid radioactive waste treatment systems; the TES unit system located in the EPR nuclear auxiliary building (NAB) and the 8TES system located in the UK EPR waste treatment building (ETB). The 8TES system will comprise of effluent storage facilities for the resins and evaporator concentrates and conditioning facilities for the raw solid radioactive waste from the nuclear island and the ETB that results from normal operation. The TES unit system will handle the filter replacement and the transfer of resins from the NAB to the ETB. A filter handling machine will remove the used filters and place them in a concrete enclosure. Spent resins will be pumped to the 8TES storage tanks of the ETB by the 8TES system. EDF and AREVA propose that resins, filter contents, and other ILW will be encapsulated in concrete containers. There will be an installation in the ETB for compacting low-activity operational waste. All conditioned waste will then be kept on site for interim storage before being sent off-site to a final storage location or to a treatment plant for additional processing (for example, incineration, smelting etc). The treatments, conditioning and packaging of operational solid radioactive waste is presented in PCERsc6.3 Table 3 and detailed in PCERsc6.4. EDF and AREVA provide further information on other potential waste management arrangements in the ETB in the SRWSR to accommodate different operators.

683 In response to additional queries raised by ONR as part of its Step 4 assessment on conditioning of waste produced by the UK EPR, EDF and AREVA provided further information in December 2010. This included more detailed information on conditioning spent resins, using a mobile machine process, and complementary information on the operation of the filter changing machine and encapsulation of filters and dry active waste (greater than 2 mSv h^{-1}), and the ETB. This information is in the radioactive waste conditioning report (see Schedule 1 of Annex 1).

684 The characteristics of decommissioning conditioned waste are given in PCER chapter 5 and in the SRWSRs.

685 C1 and C4 concrete containers (these containers are 15 cm thick and have the physical capability to last and confine radioactivity for more than 300 years) are used for packaging ILW in the reference case (PCERsc6.3). Other options for packaging ILW in stainless steel and cast iron containers for disposal are mentioned in the SRWSRs7.4.2.

686 ILW will be stored on the UK EPR sites in dedicated building(s) until a final disposal site for ILW is opened in the UK. The radioactive decay during interim storage of ILW due to its composition of short-lived radionuclides can reduce the final quantities of ILW to be disposed of. Some of this waste could be reclassified as LLW. The ILW interim storage facility will be designed to be in operation for up to 100 years after first fuel loading.

687 Design information on possible option(s) regarding interim storage facilities for ILW is provided in PCERsc6.5 and in the SRWSR. Designs for two ILW storage options are described. These can be adapted to store additional ILW that is generated during decommissioning.

688 Disposability of operational ILW is discussed in PCERsc6.5. In order to assess the disposability of ILW, EDF and AREVA provided the Nuclear Decommissioning Authority (NDA) with a datasheet for each of the UK EPR waste streams. Each datasheet included information on the nature of the waste stream, rate of arising, proposed matrix, package type, physical and chemical composition and radionuclide inventory, package heat output and external dose rate. EDF and AREVA have provided us with datasheets for the following operational waste types:

a) spent resins (ILW) raw waste;

b) spent cartridge filters (LLW + ILW);

c) operational waste (LLW + ILW);

d) wet sludges (LLW + ILW);

e) evaporator concentrates (LLW + ILW).

689 EDF and AREVA have provided us with datasheets for the following decommissioning waste types:

a) lower internals from EPR pressure vessel: heavy reflector, lower support plate, lower heavy reflector support;

b) upper internals: upper support columns and upper core plate. Lower internals: core barrel, flow distribution device;

c) reactor vessel: parts from the reactor vessel near the core.

690 EDF and AREVA have obtained and provided to us a view from the Radioactive Waste Management Directorate (RWMD) of the Nuclear Decommissioning Authority (NDA) (as the UK authoritative source) on the disposability of their proposed arisings of ILW. RWMD concluded that compared with legacy waste, no new issues arise that challenge the fundamental disposability of the waste expected to arise from operation of the UK EPR (see Schedule 1 of Annex 1). EDF and AREVA also provided the Regulators with their critique of the RWMD disposability assessment, which considered the impact of RWMD's disposability assessment on their plans for conditioning, storing and dispatching the waste to a repository.

691 Since our consultation, NDA has published a generic Disposal Systems Safety Case (gDSSC) for a future Geological Disposal Facility (GDF), based on its understanding of the scientific and engineering principles supporting geological disposal (RWMD, 2010). NDA has also provided a report regarding the impact of the gDSSC on its previous new build disposability assessments undertaken for RPs to support GDA submissions (RWMD, 2011). The report concludes:

a) '*The original 2009 GDA Disposability Assessments concluded that ILW and spent fuel from operation and decommissioning of an AP1000 or EPR raised no new disposability issues when compared against legacy wastes and existing spent fuel. These assessments have been reviewed in the light of recent developments to disposal concepts and generic safety assessment methodologies as applied in the generic DSSC.*

Overall, the changes in concept, assessment methodology and assumptions regarding parameter values have only minor impacts on the findings of the original GDA Disposability Assessments. The review therefore confirms that there are no new issues arising from the generic DSSC that would challenge the fundamental disposability of the wastes and spent fuel expected to arise from operation of the AP1000 and EPR. This conclusion is supported by the similarity of the wastes to those expected to arise from the existing PWR at Sizewell B, which are included in the generic DSSC Baseline Inventory and have been found to be acceptable.'

692 The Regulators requested further information on the volume and radionuclides / activity for waste, including rod cluster control assemblies (RCCAs); redundant irradiated control rods; neutron source assembly and poison rod assemblies, including evidence that they will be disposable. EDF and AREVA confirmed that they consider RCCAs and redundant irradiated control rods to be the same and would be ILW, and explained that there are no distinct poison rod assemblies since burnable poison, gadolinium, is mixed with uranium dioxide in some fuel assembly

rods with low uranium-235 enrichment. EDF and AREVA provided information on the volume and radionuclides / activity, and on interim storage proposals and packaging for disposal. EDF and AREVA state that it is expected that this waste would be accepted in a geological disposal facility. RWMD state that RCCAs were not included in the initial disposal inventory supplied by EDF and AREVA, although these items may have high specific activity, they will not be of large volume, and, therefore, are not expected to affect disposability of wastes from a UK EPR. They also state that these components could be managed as ILW or, given their dimensions, packaged as a complete unit with their associated fuel assembly. The RCCAs are longer than the spent fuel, but can be reduced in size by removing the end supports. Hence, RWMD said that in any future submission under the Letter of Compliance (LoC) process, the operator should provide further information on proposals for the management of RCCAs. This is covered by assessment finding UK EPR-AF10 (see below).

693 The Regulators requested EDF and AREVA to make a case for the disposability of spent fuel and ILW, which demonstrates the following:

a) How the issues identified in their critique of RWMD's Disposability Assessment will be addressed.

b) How the issues in Appendix B of RWMD's Disposability Assessment will be addressed.

c) How they will manage any risks associated with these issues.

694 EDF and AREVA provided information in February and March 2010. We note in particular that EDF and AREVA have consulted with RWMD specifically on the stages in the LoC process at which they would expect issues to be addressed. We recognise that, in most cases, these issues will need to be addressed by future operators of UK EPRs, rather than by EDF and AREVA, and we understand that EDF and AREVA have also discussed the timing of resolution of these issues with the potential UK EPR operator.

695 Since our consultation was published, EDF and AREVA have provided further information in January 2011 on their plan for disposability of ILW which includes the plan for long-term storage and the work being undertaken by RWMD (see Schedule 1 of Annex 1). The plan outlines the activities necessary to provide further confidence that ILW is disposable.

696 In general, we consider the plans proposed by EDF and AREVA, outlining how and when they and future licensees will address the outstanding disposability issues, to be adequate at this stage. We will expect these plans to be periodically refined and updated in future to reflect developments. We will expect prospective licensees to make progress on demonstrating disposability at the earliest reasonable opportunities rather than waiting for dates specified in the plan.

697 We note that EDF and AREVA have produced a 'mapping document', intended to indicate where the information that will be needed for future radioactive waste management cases (RWMCs) will come from, and when. This document gives us assurance at this stage that RWMCs can be compiled at relevant stages in the development of a UK EPR fleet, which is sufficient at this stage of the GDA process.

698 In January 2011, EDF and AREVA provided an updated 'mapping document', which incorporates comments from the Regulators and a review of all relevant documents that have been submitted as part of GDA since the original mapping document was submitted. The document gives us sufficient assurance for this stage of the GDA process that RWMCs can be compiled at relevant stages in the development of a UK EPR fleet.

699 We have assessed this further information on disposability from EDF and AREVA and their updated mapping document and have identified the following assessment finding:

a) The future operator shall provide confidence that adequate RWMCs, supported by appropriate stage LoCs, can be developed for all ILW on the timescales identified in EDF and AREVA's plan for disposability of ILW. (UK EPR-AF10)

700 ONR has reviewed information on long-term storage of ILW in its Step 4 assessment. We have worked jointly with ONR throughout the GDA process in the area of solid radioactive waste assessment and our conclusions are consistent.

701 EDF and AREVA state in PCERsc6.3 that they currently envisage reducing the sources of solid waste volume compared to feedback experience as follows:

a) designation at the design stage of clean-waste zoning, enabling sorting of waste at source and segregating conventional waste from non-contaminating work in the restricted area;

b) better control of source term through carefully selecting materials in contact with the primary coolant, which then leads to reduced production of corrosion products (a reduction in cobalt-60 activity in particular);

c) optimisation of the chemical treatment of primary coolant;

d) a greater surface area on the CVCS purification filters than on the 1300 MWe and N4 units (predecessors to the UK EPR), through using multi-cartridge baskets and not single cartridge.

702 EDF and AREVA state that it should be noted that the volume of solid waste depends on the balance between environmental discharges and packaged waste generation in managing the installation and may, therefore, change according to the various effluent treatment methods.

703 EDF and AREVA state in PCERsc8.2 that an 'EPR environment' design review took place in October 2004. One recommendation from this was to reduce the volume of solid waste, in particular by optimising the room zoning and a detailed analysis of the operating procedures and waste inventory of the existing units. They claim that they will reduce the volume of solid waste by ensuring waste is segregated as it is generated, mainly during maintenance operations in the nuclear buildings (PCERsc8.2s2.3). We accept this review finding. The Committee on Medical Aspects of Radiation in the Environment (GDA129) commented that they commend this approach aimed at minimising solid waste production.

704 In PCERsc8.2, EDF and AREVA describe how they consider that BAT has been applied to each significant waste stream. EDF and AREVA claim in their BAT demonstration report (EPRB) that BAT is being applied in the design of the UK EPR to minimise radioactive waste at source and to minimise the impacts of the disposal of waste into the environment. Having reviewed this information, we accept that the UK EPR uses BAT to minimise the arisings of ILW subject to assessment finding UK EPR-AF11.

705 PCER chapter 5 and the SRWSR states that the UK EPR design will enable decommissioning to be performed whilst minimising radiation doses to workers and minimising radioactive waste generation. They discuss the following features that have been incorporated into the design:

a) choice of materials of construction to minimise activation;

b) optimisation of neutron shielding;

c) optimisation of access routes to nuclear areas;

d) reactor systems design;

e) ease of removal of major process components;

f) submerged disassembly of reactor pressure vessel;

g) modular thermal insulation;

h) fuel cladding integrity;

i) design for decontamination;

j) prevention of contamination spread;

k) minimisation of hazardous materials.

706 EDF and AREVA state that improvements and provision are included in the UK EPR design based on feedback experience, in order to avoid replacing during the UK EPR's 60 years of operation large one-off items such as reactor pressure vessel heads and steam generators. They also state that good chemistry management during operation should prevent the build up of crud and activity due to contamination inside the tubes, over the steam generators' operating life. (PCERsc6.3s3.2.6).

707 Comments on ILW received from the public involvement process relating to the UK EPR design by 4 January 2008 were addressed in our preliminary assessment report (Environment Agency, 2008a). One comment on this subject was received during our detailed assessment stage. The comment asked whether the UK EPR design adequately caters for the encapsulation, storage and disposal of ILW. EDF and AREVA responded with information that is available in their submission, that is that ILW is encapsulated in concrete containers and that final ILW packages will be placed in an interim storage facility before their disposal in the proposed GDF.

708 One of the questions raised at the stakeholder seminar was: '*Disposability of waste and spent fuel – not covered adequately in consultation / public domain. What are the options and timescales?'* Disposability of solid radioactive waste was discussed in chapter 11 of the consultation document and spent fuel in chapter 12. This included information on options and timescales but we note that additional information is available in our assessment reports. The assessment reports are published on our website. Additionally, since our consultation was published, as mentioned above, we received further information from EDF and AREVA on disposability in January 2011 (see Schedule 1 of Annex 1).

709 Another question raised at the stakeholder seminar, was what are the options for the storage of intermediate and high level waste, both on-site and off-site, and what are the most likely options and why. As stated above, design information on possible option(s) regarding interim storage facilities for ILW is provided in PCERsc6.5 and in the SRWSR. Designs for two ILW storage options are described. The option that will be chosen is dependent on the operator.

710 At the stakeholder seminar, the following comment was made: '*CoRWM recommended that new build waste be subjected to a separate process. This waste is of a different order, and should have its own safety case*'. It is the responsibility of the NDA to develop a safety case for any proposed geological disposal facility.

711 Blackwater Against New Nuclear Group (BANNG) (GDA112) provided the following response to our consultation: '*It is proposed to manage long-lived solid radioactive wastes (ILW) and spent fuel on site. There are two problems here. The first is that the methods of management are not specified in detail and may be subject to variation. It is assumed that wastes will eventually be disposed of in a geological repository and, in the meanwhile, will be appropriately managed. ILW will be immobilised and encapsulated and stored on site or possibly moved to another*

(regional or central) store until a repository becomes available. Beyond this the design details are vague and the Regulators are clearly unsatisfied with the level of information provided. In the case of ILW they require 'more information on the potential for degradation of ILW over the longer term that might affect disposability and safe storage' (p.85). More information will be required on proposed storage facilities. In particular the risks to workers, the environment and to the population arising from encapsulation, waste transfer and transport needs to be assessed and there is precious little information on these matters. The Regulators regard the management of these wastes as a key issue and will be looking in more detail at the plans in its Step 4 assessment. Indeed, it may be said that the information supplied in the consultation document is vague and far too flexible. Therefore in answer to Question 6, BANNG considers the response by the Regulators to be complacent and inadequate. In our view the Regulators should call for a much more detailed and robust explanation of proposed ILW storage together with details of the methods and facilities required and indicate that this should be supplied as part of the current assessment and not delayed until Step 4'.

712 Kent Against a Radioactive Environment (KARE) (GDA147) and Bradwell for Renewable Energy (GDA121) said that they fully endorse BANNG's response to the Generic Design Assessment consultation.

713 The Regulators received additional information from EDF and AREVA in January 2011 (see Schedule 1 of Annex 1) that we have assessed and this is discussed above. We note that ONR regulates nuclear safety, including the safe management, conditioning and storage of wastes on nuclear licensed sites, and DfT regulates the safe transport of radioactive material.

714 An individual respondent (GDA119) said that it is highly likely that a waste repository will never be built and the stores should be designed to fulfil all requirements on the assumption that high level waste and spent fuel will be on site permanently. Another individual respondent (GDA135) stated that the conclusions drawn rest on the assumption that geological disposal of ILW is technically achievable and that this is at best speculative and not supported by the available evidence. Communities Against Nuclear Expansion (GDA48) said that there is no proven safe way of disposing of nuclear waste and as a result have to store it for timescales beyond the human imagination, at least ten thousand and maybe up to two hundred thousand years. West Somerset Council and Sedgemoor District Council (GDA154) said that they are concerned with potential risks associated with the delay and delivery of the GDF programme, which runs the risk of continued need for on-site ILW and spent fuel stores until an ultimate disposal route is established.

715 Additionally, at our stakeholder seminar, concerns about the GDF and the fall back for the storage for the lifetime of waste if the GDF falls through were raised. Another individual respondent (GDA14) raised similar concerns on the AP1000 which is also applicable to the UK EPR: '*Westinghouse's radioactive waste and spent fuel strategy does all it can do within the boundaries and uncertainties of UK policy and waste facilities. This would, in the event that multiple new build reactors are commissioned and the GDF programme is unchanged or delayed, run the risk of several / many isolated waste and spent fuel stores on otherwise decommissioned reactor sites. Some form of centralised UK waste storage would probably be more optimal for many points of view – but there is time for such optimisation to be considered.*' Nuclear Waste Advisory Associates (NWAA) (GDA133) and the UK and Ireland Nuclear Free Local Authorities (NFLA) (GDA82), both provided the following point in the conclusions of their responses and the Nuclear Consultation Group (GDA149) quoted this from NFLA: '*At present it is quite apparent the nuclear industry would not be able to dispose of new build reactor*

wastes safely. It would be wholly irresponsible to wait until such wastes are created to confirm this. Unless and until the nuclear industry are able to demonstrate that new reactor wastes could be disposed of safely there should be no further steps taken towards the development of new reactors.' They also quoted this from Blackwater Against New Nuclear Group: '*Regulators must suspend the GDA process until such time as there is adequate information provided on how the wastes arising from new build will be managed and there is in place a long-term management solution that is scientifically robust and socially acceptable*.' A similar comment from our stakeholder seminar was: '*Concern with the whole waste management issue – GDA fails to consider adequately waste management – has no answers – relies on disposal / repository being available – not certain? The concept of a central store is new – what does this mean?*'

716 Government considered the issue as to whether ILW and spent fuel should be created by new reactors prior to the availability of a GDF when it consulted on energy policy. We note that DECC has published its response to the consultation on the Draft National Policy Statements (NPS) for Energy Infrastructure. With respect to radioactive waste management, DECC had asked the following question in its consultation: '*Do you agree with the Government's preliminary conclusion that effective arrangements will exist to manage and dispose of the waste that will be produced by new nuclear power stations in the UK?'* Having considered carefully the responses to this question, the Government has concluded that it is satisfied with the preliminary conclusion set out in the draft NPS. The Nuclear NPS confirms that the Government is satisfied that effective arrangements will exist to manage and dispose of the waste that will be produced by new nuclear power stations in the UK. We note that CoRWM have said that the Government must judge whether all the arrangements will exist by the time they are needed (CoRWM, 2010). We also note that the Government base case for new build is that a facility for long-term storage of high level waste and spent fuel will be available in time to receive the wastes from new reactor build. With respect to the comment on a central store, this is outside the scope of GDA.

717 Studsvik UK Ltd (GDA131) provided the following response: '*Incineration or grouting of ion-exchange resin can not be considered BAT. Technologies such as steam reforming will minimise the waste from the ion exchange resin with a factor 7 to 30 depending on resin type, loading and boron content*.' Additionally, Nuclear Waste Advisory Associates (GDA133) and the UK and Ireland Nuclear Free Local Authorities (GDA82), both provided the following point in their responses: *'EDF assume that certain ILW can be incinerated leaving no radioactive residue. The EA state that this assumption: "needs further explanation" – and that the incineration of ILW would be "novel". The EA should rule out incineration of these wastes at this stage, as it would clearly fail to meet the requirement 'Best Available Techniques'*. Stop Hinkley (GDA157) said that they are appalled that an operator may incinerate ILW just to reduce the volume of waste. RWMD said in its disposability assessment that: *'The EDF and AREVA submission assumed that, in the Reference Case, evaporator concentrates would be incinerated leaving no radioactive residue, which is the current practice in France.*'

718 The assumption cited by RWMD that evaporator concentrates can be incinerated leaving no radioactive residue will need clarification in LoC submissions and in the RWMC if a future operator proposes such incineration. However, EDF and AREVA note that the evaporator concentrates in France that are incinerated are LLW, and not ILW. We require evidence during the detailed design phase that the proposed specific techniques for treating and conditioning of ILW before disposal are BAT (UK ERP-AF12). We have also identified the following assessment finding:

a) If incineration of any intermediate level waste (ILW) is pursued, the future operator shall, demonstrate that the conditions of acceptance of any available incineration facilities can be met (UK EPR-AF15).

719 Nuclear Waste Advisory Associates (NWAA, GDA133) and the UK and Ireland Nuclear Free Local Authorities (GDA82), both provided the following comment on radioactive carbon in ILW in their responses: '*Work by Nirex has indicated that carbon from a nuclear disposal facility could escape as radioactive methane gas and carbon dioxide. This would be able to quickly reach people at the surface. Nirex have calculated the resultant risk could be as high as 100 times the allowable limit as soon as the dump has been closed. There would be a relatively large inventory of radioactive carbon in decommissioning waste. The NDA's Radioactive Waste Management Division (RWMD) says this need not be a significant concern. The EA says these arguments are rather speculative at this stage and will need to be underpinned more convincingly. Yet EA recognise the NDA is unlikely to have more confidence in their risk estimates associated with radioactive carbon in repository-generated gases before a site for the GDF has been selected. So there will be a continuance along the road of new reactor construction before there is knowledge of whether or not waste containing radioactive carbon can be 'disposed' of safely*.'

720 We agree that this matter needs to be resolved, but on the balance of the evidence to date we see no compelling reason to conclude that it cannot be resolved. The details of gas migration from the GDF – which will determine the impact – are expected to be very site-dependent and so can only really be addressed when a site has been identified.

721 The UK and Ireland Nuclear Free Local Authorities (GDA82) provided the following comment on waste in their response and the Nuclear Waste Advisory Associates (GDA133) and Greenpeace (GDA151) provided very similar ones: '*Information from the nuclear industry on the 'disposal' of waste from new reactors is available in several reports. However, at Section 3.3 of the EA assessment reports on the disposability of ILW and spent fuel, a number of unspecified issues are referred to that the EA has raised with the nuclear industry. Neither the issues – nor the industry response is made available to the Public. The Agency states that it recognises these issues will have to be addressed at some unspecified point in the future, but that in general they consider plans for dealing with them are adequate. In the NFLA view, this kind of 'pretend' consultation is unacceptable. It makes it difficult to fully respond to the consultation without knowing this important information – what are the unspecified issues?*'

722 Section 3.3 of the disposability assessment report does not refer to any issues '*that the EA has raised with the nuclear industry*' – this section refers to the issues RWMD have raised in Appendix B of their disposability assessment and to a few additional issues raised by EDF and AREVA in their critique of the disposability assessment. EDF and AREVA have published the full disposability assessment, including Appendix B and their critique on their web site.

723 Nuclear Waste Advisory Associates (GDA133) and the UK and Ireland Nuclear Free Local Authorities (GDA82), both provided the following comment on waste in their responses: '*To predict the contamination of water or gas that could leak from a nuclear disposal facility, the chemical characteristics and surroundings of the radioactive atoms must be known. However, inventory information set out in the NDA 'Disposability Assessment' reports is limited to information on the 'atom type' (the 'isotopes') alone – not the characteristics and chemical surrounding of these atoms. The critical importance of this type of information may be appreciated by comparing the solubility of carbon in a diamond and carbon in sugar. In one*

chemical form the carbon will not dissolve at all – whilst in the other form the carbon is completely soluble. Although there is some mention in the Disposability Assessments of the presence of materials such concrete and cellulose that would affect the chemical environment, to all intents and purposes, the information required is simply absent. Therefore, there is no way in which the NDA would be able to realistically predict how contaminated the leaks for a nuclear dump would be. This means their risk calculations do not reflect the reality.'

724 RWMD's assessments of post-closure impact from disposed wastes are based on assumptions about the physical and chemical forms of waste, which are in turn based on knowledge of the materials making up the wastes and their proposed conditioning and packaging. Potential release rates of radionuclides from the wastes, either in groundwater or as gases, are estimated from either detailed modelling of the evolution of the chemical environment of the GDF (based on the expected materials and conditions) or on simplified – generally pessimistic – models informed by more complex analysis of the chemistry. The behaviour of radionuclides in solution in groundwater or as a gas also takes account of the chemistry, and where there is real doubt about the chemical form, the form leading to the highest impact is typically assumed.

725 The UK and Ireland Nuclear Free Local Authorities (GDA82) provided the following comments on waste disposal in their response and the Nuclear Waste Advisory Associates (GDA133) provided very similar ones:

a) '*The EA has set a limit on the risk that may be caused by the burial of radioactive wastes of* 10^{-6} yr^{-1} *(i.e. one person in a million per year contracting a fatal cancer, a non-fatal cancer or inherited genetic defect as a result of radiation exposure). In comparison the NDA calculates the dose from the spent fuel arising from 6 new EPR reactors (almost 10GW) would be more than half this total risk. As the Agency points out: "...this does not leave a large margin to the regulatory risk guidance level". The (November 2009) Draft "Nuclear National Policy Statement" (27) proposed ten reactors sites, each with up to two reactors. Thus, in addition to current wastes, the wastes from up to 20 new reactors would need to be considered. The assumption that the nuclear industry may meet the regulatory target of a 'one in a million' risk simply by beginning the construction of an additional disposal facility cannot be legitimate. A second dump would result in double the original dose – even if this was spread geographically. It should also be noted that a large number of problems have been identified with the NDA's disposal project indicating that the NDA dose figures represent an extreme underestimate. For example, in March 2010 Nuclear Waste Advisory Associates (NWAA) compiled a register of current technical issues which remain to be resolved if a technical case for radioactive waste disposal is to be made. Over one hundred issues were identified. The EA simply states that: "At the time of disposal it will need to be confirmed by the GDF [disposal facility] licensee that the performance of the GDF with its whole inventory will be consistent with our risk guidance level". At present it is quite apparent the nuclear industry would not be able to 'dispose' of new build reactor wastes safely. It would be wholly irresponsible to wait until such wastes are created to confirm this. Unless and until the nuclear industry are able to demonstrate that new reactor wastes could be disposed of safely there should be no further steps taken towards the development of new reactors'.*

b) *'The Environment Agency's 'generic' evaluation of new reactor wastes prior to construction is meant to avoid a similar situation re-occurring. The Government says that potential new reactor developers have made clear they want national issues to be dealt with in advance of a public inquiry otherwise they will not consider investing in new nuclear power stations. Similarly, the Environment*

Agency says a key objective of utility companies is that uncertainties associated with regulatory matters are reduced so they can make well informed commercial decisions. The Environment Agency oversees waste issues associated with the nuclear industry, including nuclear waste 'disposal'. The NFLA would have been expected, therefore, that the Agency would look in some detail at the disposability of spent fuel from new reactors. The NDA's Radioactive Waste Management Division (RWMD) has produced reports on behalf of the nuclear industry on the disposability of nuclear waste and spent fuel arising from both EPR and AP1000 reactors. The nuclear vendors, or Requesting Parties (RPs) as they are known, responded to RWMD's Disposability Assessments. Yet the EA's consideration of this issue in the Consultation Document covers just seven out of over 170 pages. The report highlights several technical issues that are not fully resolved. Crucially, the EA has already stated that it is not known whether or not it will be possible to safely 'dispose' of waste fuel. But, in effect, the Agency postpones these outstanding disposability issues to some unspecified time in the future. The EA has produced additional 'assessment' reports on waste fuel and also the disposability of Intermediate Level Wastes (ILW) and waste fuel. These reports also indicate the EA plans to postpone the question of whether or not safe disposal is achievable. The EA states that it expects EDF: "...to identify at least one complete credible route by which the higher activity wastes from a fleet of UK EPRs could be safely disposed of and to provide grounds for reasonable confidence that the route(s) could be followed successfully." It is difficult to see how such a 'credible route' can be identified at this stage when the NDA's RWMD has yet to publish its draft safety case for the GDF, and when there are so many unresolved uncertainties regarding the deep geological disposal of nuclear waste. The fact that the outcome of future research may be that wastes cannot be 'disposed' of safely has been referred to extensively by the EA. It is imperative this issue is resolved prior to the expenditure of billions of pounds on reactor construction. If the nuclear industry is not required to prove they have a safe disposal route for wastes until after the planned reactors are built, then a powerful financial momentum would be created towards allowing the reactors to operate – and so produce waste fuel for which there was no long term safe management route. This should be a 'deal-breaker' for new reactors yet the EA simply chooses to postpone the problem until some unspecified time in the future. This is wholly irresponsible.'

c) *'For both types of reactor, the EA propose to issue an interim certificate to state the designs are 'acceptable' – pending the resolution, at some stage, of the 'disposability' issue. What the NDA's has called "disposability assessments" were relied upon by the Government to reach the conclusion that it was "satisfied that effective arrangements will exist to manage and dispose of the waste that will be produced from new nuclear power stations." The NDA argues that – because it would not be able to use a site for disposal unless it was approved by the Regulators, then – necessarily – the chosen site would meet regulatory standards. Of course, this argument does not follow. It is possible the NDA could select a site, but be unable to meet the necessary standards. There has been a precedent for this in the rejection of the site proposed in the 1990s, partly for generic technical reasons, but partly for site-specific reasons. In March 2010, the House of Commons Energy and Climate Change Select Committee stated: "…the Government has no choice but to find a solution [for nuclear wastes], regardless of a decision on nuclear new build [and] waste arising from new nuclear power stations will not pose a significant additional challenge in terms of finding a permanent storage solution." This 'King Canute' argument that because the waste problem exists, the Government must be able to solve it, similarly makes no sense. Clearly, just because radioactive waste* *exists, it does not necessarily follow that it will be possible to safely dispose of it. The must make it clear that it rejects both of these arguments. There is no safe disposal route available for new reactor wastes, therefore the Agency must refuse to authorise its creation.*'

d) *'The EA Assessment Reports fail to fully analyse the NDA's 'Disposability Assessment' reports and the Requesting Parties responses. Instead they postpone dealing with outstanding disposability issues to some unspecified time in the future. This is unacceptable'*

e) *'The consultation documents fail to acknowledge other work by the EA which states that it is possible that an acceptable safety case for a GDF cannot be made.'* The Nuclear Consultation Group (GDA149) also quoted this from NFLA.

726 We are familiar with the NWAA's list of issues, and aware that RWMD are discussing with NWAA their responses to them, and we have ourselves raised many issues with Nirex and RWMD over the years. As stated above, the Nuclear NPS confirms that the Government is satisfied that effective arrangements will exist to manage and dispose of the waste that will be produced by new nuclear power stations in the UK. We also note that the Government base case for new build is that a facility for long term storage of high level waste and spent fuel will be available in time to receive the wastes from new reactor build. As mentioned above, we have received additional information from EDF and AREVA in January 2011 (see Schedule 1 of Annex 1). We have assessed this further information and have identified the following assessment finding: The future operator shall provide confidence that adequate RWMCs, supported by appropriate stage LoCs, can be developed for all ILW on the timescales identified in EDF and AREVA's plan for disposability of ILW (UK EPR-AF10).

727 The Institution of Mechanical Engineers (GDA145) provided the following response to our consultation: '*Notwithstanding that the Generic Design Assessment is not intended to cover Site-specific Issues the potential for adjacent nuclear facilities to provide storage of radioactive waste and monitoring of radioactive waste discharges should be recognised*.'

728 Adjacent facilities are outside the scope of GDA. However, we would encourage operators to work with adjacent operators where they exist to reuse existing facilities.

729 NNB Genco (GDA106) provided the following response:

a) *'We welcome the Environment Agency's conclusions on solid radioactive waste, that all waste streams have been identified and that proven and recognised treatment and conditioning techniques will be used. NNB GenCo will work with RWMD and Regulators to ensure that conditioning of ILW does not foreclose options until a Letter of Compliance (LoC) has been approved which demonstrates that packages will be disposable following long term interim storage'*

b) *'We welcome the Environment Agency's conclusion that Intermediate Level Waste (ILW) from a fleet of UK EPRs would be disposable in a suitably designed and located UK Geological Disposal Facility (GDF), subject to a satisfactory demonstration that spent fuel can be stored safely for the necessary period of time without significant degradation. This is in accord with the evidence provided by the Requesting Parties. Outside of the GDA process, prospective operators including NNB GenCo are already working with the Radioactive Waste Management Directorate (RWMD) to progress key issues, including the duration of interim storage prior to emplacement and the optimisation of the GDF design for both legacy and new build waste. These are* *operator and site-specific issues, and we do not believe it is appropriate for the Requesting Party to seek further commitments from RWMD as part of the GDA process beyond the disposability assessment that has already been provided. We recognise that prospective operators will need to continue to work closely with Regulators and RWMD as the design of the GDF develops, so as to ensure that conceptual Letters of Compliance are in place at the appropriate time*'.

730 Horizon Nuclear Power (GDA127) provided the following response with respect to the issues raised in our consultation document on ILW:

a) '*The disposability of ILW following longer term interim storage. We are confident that it will be possible to conclude that ILW can be safely stored over the longer term and that it will then be possible to dispose of it. Many thousands of packages of legacy ILW at Nuclear Decommissioning Authority (NDA) owned sites have already been prepared with the expectation that these will be disposable and the NDA / Radioactive Waste Management Division (RWMD) has issued Letters of Compliance to provide confidence that this will be the case. Horizon recognises that it will need to continue to engage with the RWMD to obtain appropriate Letters of Compliance for our site-specific proposals.'*

b) *'Evidence during site-specific permitting that specific arrangements for minimising the disposals of LLW and ILW are BAT: Horizon is aware that during site-specific permitting it will need to present information to demonstrate BAT. Minimising the disposals of LLW and ILW is intimately linked with how the reactor is operated, what discharge abatement technology is deployed and what conditioning and packaging technologies are used. Minimising the quantities of waste for disposal is not something that can be targeted in isolation but will instead be a balance between a number of competing issues such as operator doses and environmental discharges.'*

731 The Regulators received additional information from EDF and AREVA in January 2011 (see Schedule 1 of Annex 1) that we have assessed and this is discussed above. We agree that operators should use BAT to achieve a high degree of protection of the environment, taken as a whole and to meet the principle of optimisation.

732 Several respondents, including; individual respondents (GDA25, GDA84), the Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA67), Springfields Site Stakeholder Group (GDA96), Horizon Nuclear Power (GDA127) and the Institution of Mechanical Engineers (GDA145) said that they were satisfied with our conclusions on solid radioactive waste.

733 The Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA67) noted that the uncertainty regarding disposability of long-term stored ILW is a generic UK issue rather than a design specific or site-specific issue.

734 The Institution of Mechanical Engineers (GDA145) said that they fully support the requirement for the assessment of disposability of ILW following longer term interim storage pending disposal as the uncertainty surrounding the ILW repository means we must have assurance of the efficacy of long term interim storage. Again, as stated above, the Regulators received additional information from EDF and AREVA in January 2011 (see Schedule 1 of Annex 1) that we have assessed and this is discussed above.

735 EDF and AREVA have provided valid estimates for the annual arisings (during operations and decommissioning) of ILW. These arisings (during operations) are consistent with those of comparable reactors around the world (Isukul, 2009). The arisings of ILW are below the European Utility Requirement (European Utility Requirements for LWR Nuclear Power Plants Rev C Apr 2001 (Volume 2 chapter 2,

section 5.2)) objective of less than or equal to 50 m^3 per 1000 MWe plant-year of operation.

736 On the basis of the information provided for GDA, we see no reason at this stage to believe that any of the ILW from a UK EPR will not be disposable in a suitably designed and located GDF. **We conclude that the UK EPR is not expected to produce ILW for which there is no foreseeable disposal route.**

737 **In due course, we will need to see more definitive assessments to confirm how all of the ILW will be conditioned for disposal, that the selected conditioning methods represent the application of BAT, and that in their conditioned forms the ILW will continue to be disposable. Our conclusion is, therefore, subject to an assessment finding:**

a) **The future operator shall provide confidence that adequate radioactive waste management cases (RWMCs), supported by appropriate stage Letters of Compliance (LoCs) can be developed for all intermediate level waste (ILW) on the timescales identified in EDF and AREVA's plan for disposability of ILW. (UK EPR-AF10).**

11 Spent fuel

11.1 Conclusions

738 Our conclusions have been updated since our consultation.

739 **We conclude that EDF and AREVA have:**

a) **demonstrated BAT in the fuel design for the UK EPR in order to minimise the amount of spent fuel for disposal;**

b) **provided sufficient evidence to support the safe short and longer term interim storage of the spent fuel to support the condition of the fuel for disposal.**

740 **We also conclude, based on the further evidence provided on EDF and AREVA's management plans for the fuel including storage, that the UK EPR is not expected to produce spent fuel for which there is no foreseeable disposal route**.

741 As part of our assessment we identified the following assessment findings:

a) The future operator shall, before the commissioning phase, propose techniques for the interim storage of spent fuel following a period of initial cooling in the pool. The future operator shall provide an assessment to show that the techniques proposed are BAT. (UK EPR-AF16)

b) The future operator shall, before the commissioning phase, provide confidence that adequate Radioactive Waste Management Cases (RWMCs), supported by appropriate stage Letters of Compliance (LoCs) and taking due account of necessary storage periods, can be developed for spent fuel on the timescales identified in EDF and AREVA's plan for disposability of spent fuel. (UK EPR AF17)

11.2 Background

742 In this section we cover our assessment of the creation and management of spent fuel. There are currently no final disposal facilities for spent fuel in the UK. However, the Government has stated (BERR, 2008a) that it is satisfied that:

a) a geological disposal facility would provide a possible and desirable mechanism for disposing of higher level wastes (both from a new nuclear programme and existing legacy waste);

b) there are feasible and long-term mechanisms through the MRWS (Defra et al 2008) programme for identifying a suitable site and for constructing a geological disposal facility.

743 Although a permit for final disposal may not be required for a considerable time, we expect EDF and AREVA to show now whether spent fuel:

a) is likely to be suitable for disposal in a geological repository;

b) will be appropriately managed in the interim, so as not to prejudice its ultimate disposal.

744 We addressed comments we received on spent fuel from the public involvement process relating to the UK EPR design by 4 January 2008 in our preliminary assessment report (Environment Agency, 2008a). Public comments on this topic were received during our detailed assessment stage. One comment requested information about the type of spent fuel cask that would be used to transport spent fuel for processing or disposal. EDF and AREVA's response confirmed that TN type transport casks would be used to transport spent fuel in the UK. Information about the casks is provided in the SRWSR. The TN cask is a dual purpose cask that can be used to store and to transport spent fuel.

745 A comment was received about storage of spent fuel following the closure of reactor operations, and the need for ongoing secure power supplies to service the spent fuel storage pools, water treatment systems, waste treatment systems and storage facilities. The comment also queried whether the design of the dry storage casks would take into account the varying enrichment levels of the fuel elements. EDF and AREVA's response confirmed that the technology for longer term spent fuel management is not chosen, although several options are available such as dry cask or dry vault storage, or long term pool storage. Their response also confirmed the design of the storage facilities will take into account the enrichment and residual heat of the spent fuel elements, whatever technology is chosen. With regard to the ongoing availability of electrical power for services following reactor closure, it was confirmed that it is the aim of the UK national energy policy to ensure security of supply, together with the integrity of back up power supplies to provide power in the event of loss of grid supplies. Back up power supplies are addressed by the ONR, and it is noted that some store technologies utilise passive methods.

746 A large number of the consultation responses for both designs considered in GDA were in regard to the issues of waste and spent fuel storage and disposal. Responses were made in regard to issues including the use of high burn up fuel requiring extended storage, the long period of interim storage for spent fuel prior to disposal, the integrity of fuel following storage, the integrity of the fuel store over time, whether centralised stores would be available, whether an encapsulation plant for spent fuel would be required on the reactor site, and about the availability of the GDF in the expected timeframe. These are discussed in the relevant parts of this chapter.

747 These responses have been shared with ONR given its lead regulatory role in regard to safe storage of wastes including spent fuel.

748 Questions were also raised and published from our 6 July GDA stakeholder seminar and are considered in this document.
http://www.hse.gov.uk/newreactors/seminar-060710.pdf

11.3 Creation of spent fuel

749 The UK EPR reactor core comprises 241 fuel assemblies that contain bundles of fuel rods held in place by space grips and top and bottom fittings. The fuel assembly is a 17x17 square array comprising 265 fuel rods and 24 guide thimbles. The thimbles are joined to the grids and the top and bottom nozzles. The thimbles may also hold rod cluster control assembles (RCCAs) which are used to control the reactivity of the core and power distribution, and for reactor shutdown, and neutron source rods, or in core instrumentation. The fuel is in the form of uranium dioxide (UO_2) pellets that are stacked in a zirconium alloy cladding tube to form fuel rods. Some fuel assemblies also include a neutron poison, gadolinium oxide, which is mixed with the fuel and depletes slowly with burn up.

750 One of the questions from our stakeholder seminar was whether mixed oxide (MOX) fuel would be used. EDF and AREVA claim it is possible to use MOX fuel in the UK EPR but this has not been put forward for assessment in GDA, and therefore use of MOX is out of scope. Some attendees to our stakeholder seminar also asked for details of the fuel used for both designs in GDA. Information about the EPR fuel can be found in the EDF and AREVA submission, see PCSR sub-chapter 4.2 Fuel System Design.

751 The initial enrichment of new fuel is up to 5 per cent in weight uranium-235 in order to sustain the nuclear fission reaction. The UK EPR is designed for an operational life of 60 years during which time the operational reactor will contain around 127 tonnes of enriched uranium fuel. Reactor refuelling takes place at the end of each reactor fuel cycle. The UK EPR fuel cycle lasts from 12-22 months depending on the fuel management regime adopted by the future operator. At the end of the fuel cycle, approximately one third of the 241 fuel assemblies are replaced by new fuel assemblies. The isotopic composition of the spent fuel depends on the initial enrichment, the uranium source and the fuel management conditions in the reactor. The average core region fuel burn up is less than 65,000 MWd tU^{-1}, which is the maximum burn up proposed.

752 A consultation respondent (GDA38) commented on the relatively small amount of (high burn up) fuel used in a new reactor compared with older reactors, and noted that less waste would be produced. However, other responses, including a question from stakeholders at our seminar on 6 July, raised the issue of longer lived radionuclides associated with high burn up fuel requiring longer storage periods for spent fuel. The implications of the use of high burn up fuel for storage and disposal are considered later in this chapter.

753 Both new fuel and spent fuel are stored on the reactor site in the fuel building. PCERsc1.2 describes the fuel building, which includes the spent fuel pool, the loading pit for casks, the transfer station, and storage and inspection compartments for new fuel assemblies. It also includes filtration units to filter air escaping in accident conditions and ventilation systems.

11.4 Management of spent fuel

11.4.1 BAT to minimise disposals of spent fuel

754 EDF and AREVA have used a step-by-step approach to apply BAT, as described in PCER Chapter 8. The UK EPR reference plant is Flamanville 3, which was designed to take into account experience and feedback from operating PWRs in France and Germany. This allowed improvements to be identified and incorporated as a result of learning from experience. There was an EPR environment design review in France in 2004, and an action plan and task force was set up. The scope and findings of the design review were discussed at the Regulators' inspections in December 2007 and April 2009, and presented in the published Regulators' inspection report in 2009.

755 EDF and AREVA describe the improvements in environmental performance of the UK EPR project with regard to waste and fuel include:

a) a more efficient use of natural uranium resources;

b) a significant reduction in the quantity (volume, mass) of long lived radioactive waste resulting from the fuel and its cladding owing to its:

i) neutronic design (large core, neutron reflector);

ii) and the fuel management performance (high burn up).

756 PCERsc8 describes the use of BAT in the UK EPR design with regard to spent fuel, namely the improved overall use of the fuel material compared with existing plants, as a result of increased operating and safety margins and more efficient use of the neutrons produced. There is less use of nuclear materials to produce the same amount of energy. It is possible to reduce both the consumption of natural uranium and the quantity of waste produced by irradiation, for the same amount of energy produced. Also high burn up of the fuel optimises the use of the fuel and saves approximately 7 per cent of the natural uranium resource required compared with current fuel for a given amount of energy produced.

757 EDF and AREVA claim that the UK EPR design has three design features which directly contribute to reducing natural uranium consumption and spent fuel production:

a) the use of a large core with 241 fuel assemblies compared to 205 fuel assemblies for the N4 reactor operating units; the N4 is a predecessor design to the UK EPR. There is a reduction in neutron leakage due to the larger size of the core. Adopting a larger core with a smaller refuelling fraction enables 7 per cent savings in natural uranium;

b) using a solid steel reflector, the heavy reflector. The reduction in radial neutron leakage leads to savings of 2 – 3 per cent natural uranium;

c) the improvement in overall thermal efficiency and the enhanced turbine efficiency, contributes 5 per cent to the reduction in consumption of natural uranium.

758 EDF and AREVA indicate that the reduction of solid waste arising from fuel and its cladding is linked to the UK EPR's neutronic design and the capability for improved burning of the fuel used. EDF and AREVA claim the increased burn up rate leads to a reduction in radiotoxic materials of around 14 per cent and a reduction of high activity long lived waste such as cladding of around 30 per cent. A consultation response (GDA38) also noted the reduction in waste.

759 EDF and AREVA note that the improvement in fuel reliability is a major objective for the UK EPR. Information provided indicates that the current UK EPR fuel design is based on improvements in manufacturing and quality, and research and development. There is a worldwide programme of research and development, including manufacturing and human aspects. Information on fuel failure rate is included earlier in this document; the current UK EPR fuel AFA 3G assemblies have shown high operational reliability. One of the questions from stakeholders at the 6 July seminar was about failed fuel and whether the release of tritium is assessed. Chapter 7 provides information on fuel failure and tritium.

760 EDF and AREVA have not provided information on potential discharges from interim spent fuel storage prior to disposal. We would not expect discharges from interim spent fuel storage to be significant, and would include any discharges within the limits and levels proposed for the reactor in Chapters 8 and 9.

761 We consider EDF and AREVA have demonstrated BAT in the fuel design and in order to minimise the amount of spent fuel for disposal.

11.4.2 Initial Fuel Cooling in the Pool

762 In PCERsc6.2, EDF and AREVA provide information on radioactive waste and spent fuel produced by the UK EPR. A fuel assembly is spent and must be discharged after producing energy in the reactor for a period of 3 to 5.5 years depending on the fuel cycle adopted by the operator. The fuel assembly is then transferred from the reactor building to the fuel building through the containment penetration formed by the fuel transfer tube. The UK EPR spent fuel reactor pool and transfer facility are described in PCSR chapter 9.1. Decay heat generated from the irradiated fuel assemblies is removed by the fuel pool cooling system.

763 Spent fuel assemblies are discharged from the reactor and placed into the spent fuel pool to cool and decay for a period of some years before being moved to an interim storage facility. The UK EPR design allows a storage capacity in the fuel pool for at least 10 years electricity generation.

764 The quantities of spent fuel discharged from the reactor during refuelling can be up to 80 spent fuel assemblies each refuelling operation. A bounding value for the total number of spent fuel assemblies produced at the end of reactor life is set to 3400 units.

765 Core components used to control or measure neutron activity such as RCCAs and in core instrumentation (aeroball finger tubes) may be replaced during outages. The components are highly activated when they are removed from the reactor (because of their exposure to neutron radiation in the reactor core) and are transferred to the spent fuel pool where they are left to radioactively decay.

11.4.3 Interim Storage of Spent Fuel

766 The reactor's planned operation over a period of 60 years may involve construction of an interim storage facility on the reactor site or at another location such as an interim spent fuel store shared between several sites. Any site chosen for construction of the UK EPR will require enough space to allow an interim storage facility to be constructed.

767 EDF and AREVA present a 'reference case' for solid radioactive waste and spent fuel strategy based on the waste and spent fuel management practices and arrangements of the reference plant for the UK EPR, Flamanville 3. Other possible options to the reference case for spent fuel strategy are presented in the SRWSR.

768 Five interim storage solutions are identified in the SRWSR, including underwater long-term pool storage and four types of dry storage. Wet storage is usual practice in nuclear power plants and is used for initial cooling, and subsequently may be used for interim storage, before final disposal. Dry interim storage for spent fuel is used in Europe and the USA.

769 One of the questions raised at our stakeholder seminar was '*What are the options for the storage of intermediate and high level waste, both onsite and offsite, and what are the most likely options? Why?*'. The options for storage are described in EDF and AREVA's Submission, see PCER Chapter 6.5. The Regulators issued guidance on the level of design required for waste plants in GDA, recognising the requirements for significant periods of storage for waste, and spent fuel, in particular; '*to give the Regulators the required level of confidence that the operators can safely handle, store and dispose of spent fuel viable options will have to be identified by the Requesting Parties and a strategy / plan developed to show that one of these could be developed and implemented*'. More details are below.

770 Of the five options, one wet pool storage, and two dry storage solutions were identified and assessed in more detail for the UK EPR. EDF and AREVA considered the regulatory requirements for interim storage facilities and in particular Environment Agency requirements in relation to BAT and our radioactive substances environmental principles (REPs).

771 EDF and AREVA considered three spent fuel storage technologies, based on available and proven technologies:

a) wet interim pool storage – fuel assemblies stored in a pool;

b) dry interim cask storage – fuel assemblies stored in metal casks;

c) dry interim storage in purpose designed stores – fuel assemblies stored in vault type storage.

772 The dry interim storage facility uses metallic storage flasks technology; the TN-DUO flask which is designed for both transport and storage. Information is provided on the building layout and safety features in the SRWSR. The storage facility is designed to operate for 100 years. Visual surveillance is carried out as part of a maintenance programme for flasks in the interim storage facility. A permanent check system is implemented which monitors any pressure drop in the interspace between the primary and secondary lid of the TN-DUO flask.

773 The dry storage vault involves placing fuel assemblies into canisters on receipt. The stainless steel canisters contain aluminium partitions to house fuel assemblies and ensure heat dissipation. Details are provided on the building layout and safety features.

774 These designs allow for retrieval and inspection of the fuel, and for refurbishment.

775 A member of the public (GDA66) noted their support for dry cask storage '*The transfer of the spent fuel from the pond after 10 years to dry casks is the only acceptable system'*. Our decision is both wet and dry storage systems could be used and it is for any future operator to make the choice of the interim spent fuel storage system, and to provide evidence that the chosen option represents BAT.

776 PCERsc6.5s4.1 describes the arrangements for interim storage for spent fuel. An interim wet storage facility is described with supporting review information in a report.

777 A UK EPR will generate approximately 3400 assemblies that will require storage during its 60 year operating life that will require interim storage. The interim wet storage pool facility is designed to be in operation to safely and securely store the spent fuel underwater. The lifetime of the store is about 100 years with stated objectives to maintain shielding, preserve the fuel cladding, minimise contamination, cool the fuel, maintain the sub-criticality, and to protect the fuel assemblies from mechanical damage. Potential refurbishment of the store could be considered if required beyond its 100 years lifetime.

778 The review report of interim wet storage (ELI0800224) is based on more than 30 years experience from EDF in underwater storage of spent fuel. The interim wet storage facility will be able to receive and store defective fuel assemblies associated with cladding failures. This damage may have been detected in the reactor pool or it may have occurred during spent fuel transfer or during interim storage. Defective assemblies can be inserted into over packing replacement fuel cylinders and stored in the interim wet store.

779 The design of the wet storage facility for UK EPR spent fuel is based on the latest generation of La Hague complex storage pools, and detailed information is presented in the interim wet storage report on the arrangements for receipt of

transport containers, handling and loading of fuel assemblies, cooling of the fuel pool, together with details of the building layout, safety and other relevant features.

780 The Regulators requested further information about the proposed storage facilities to support the safe long-term storage of the spent fuel and to ensure that the fuel does not degrade over the long storage period.

781 EDF and AREVA provided further information on long term storage in 2010. ONR wrote to EDF and AREVA in 2010 to indicate information on long term storage was satisfactory.

782 HPA (GDA88) responded to our consultation to note that '*when assessing the design of the interim storage facilities for spent fuel it is important that due consideration is given to minimising any waste arising from refurbishment and any doses to workers or members of the public likely to be received during refurbishment or routine operation*.' We shared this response with ONR since they are responsible for regulating dose to workers, and members of the public.

783 A respondent (GDA92) commented on dry storage of spent fuel on-site, in regard to the size and impact of the building. We consider this to be a site-specific matter and it is not considered further.

784 For transportation considerations for the transfer of spent fuel offsite, an IAEA type B transport container is required. EDF and AREVA propose to use the TN type transport containers. One option for dry interim storage considers using TN-DUO for both storage and transport of UK EPR spent fuel. The UK EPR adopts a proposed burn up of up to 65,000 MWd tU^{-1} and the TN is designed to accommodate this. Suitability of transport containers will be for the Department for Transport to address.

785 PCERsc5.2 provides information on design aspects in relation to decommissioning; the Environment Agency required EDF and AREVA to consider the whole lifecycle from design to decommissioning in their waste and spent fuel strategy. Improving the strength of fuel cladding materials significantly impacts the classification of waste by limiting the release of alpha and beta emitters. The SRWSR refers to the improvement of fuel cladding integrity to further reduce the likelihood of fuel leakages which EDF and AREVA claim are low.

786 We are satisfied that EDF and AREVA have demonstrated BAT for storage of spent fuel in the wet and dry interim options they have assessed in detail, so as to ensure that radiation exposure of members of the public from disposals of radioactive waste, including discharges, are as low as reasonably achievable (ALARA).

787 We expect the future operator to address the following assessment finding:

a) the future operator shall propose, before the commissioning phase, techniques for the interim storage of spent fuel following a period of initial cooling in the pool. The future operator shall provide an assessment to show that the techniques proposed are BAT (UKEPR AF16).

11.4.4 Time period for storage of spent fuel and fuel burn up

788 The regulation of storage arrangements for radioactive waste and radioactive material on a Nuclear Licensed Site is the responsibility of the ONR, and we have worked closely on this issue as storage may give rise to secondary arisings, and also affects eventual disposal. The responses below related to storage have been shared with ONR.

789 Questions raised at our stakeholder seminar included whether there was certainty on a long term storage facility for spent fuel being available in the foreseeable future.

790 The time period for spent fuel storage was raised in consultation responses, noting that the RP proposals are for at least 100 years after the spent fuel is first emplaced in the store. West Somerset Council and Sedgemoor District Council (GDA154) and Stop Hinkley (GDA 157) refer to a period of 160 years for on site storage of fuel – 100 years for onsite storage from the draft Nuclear National Policy Statement (NPS) and 60 years of operational life for the reactor.

791 The Welsh Assembly Government (GDA141) and Cumbria County Council (GDA166) also raised the issue of on site storage of spent fuel for up to 160 years before geological disposal. The Nuclear Legacy Advisory Forum, Nuleaf (GDA80) commented about spent fuel interim stores at each station being designed to be maintained or replaced to last for at least 100 years from when spent fuel is first emplaced in the store, and that the draft Nuclear NPS assumes that spent fuel could be stored on the station sites for up to 160 years.

792 The Nuclear Free Local Authorities, NFLA (GDA82) also raised this issue. Another respondent (GDA92) commented about the ability to control hazardous material (spent fuel) over a long period of time during on site storage, referring specifically to 160 years.

793 A respondent (GDA119) commented in regard to waste storage '*it is highly likely a waste repository will never be built...the stores should be designed to fulfil all the requirements on the assumption that high level waste / spent fuel will be on site permanently*'. As we noted above we have provided guidance in GDA on our expectations for design of waste plants to meet extended periods of spent fuel storage and we and ONR consider EDF and AREVA have provided satisfactory evidence on plans for storage in GDA.

794 The Nuclear NPS, Annex B radioactive waste management, states '*the Government does not expect on-site interim storage to be required for as long as 160 years. Moreover there are some factors which might cause this on-site interim storage period to be significantly shorter, for example it is not necessarily the case that the whole interim storage period for the spent fuel produced by a new nuclear power station will be on-site*'.

795 The NDA revisited the cooling period for spent fuel arising from new nuclear build; it had previously identified a cooling period of the order of 100 years for high burn up fuel (65 GW/tU). It was identified that the duration of storage, following the end of power station operation could be reduced to the order of 50 years before disposal, for example with the judicious mixing of long-cooled and short-cooled spent fuel. (NDA, 2010). This will help ensure that heat load limits for the individual disposal packages are not exceeded.

796 The period of storage is based on conservative options and a shorter storage period may in fact be needed.

797 The Institution of Mechanical Engineers (GDA145) responded ' *whilst the Institution fully supports the need for secure long term interim storage, what reassurance is required for spent fuel disposal? Surely this fuel is almost identical to Sizewell B*.' The disposability assessment carried out by RWMD for EDF and AREVA indicates that spent fuel is broadly similar to other fuels in the baseline inventory for a future repository. Comments from our stakeholder seminar noted that we should learn from experience in storage of spent fuel at Sizewell Nuclear Power Station. ONR GDA inspectors have liaised with their counterparts on Sizewell B fuel strategy as detailed in their Step 4 assessment report for radioactive waste (ONR, 2011c) and

we recognise that respondents to our consultation have raised issues about disposability of the fuel and a final disposal facility. These issues are discussed later.

798 Questions were raised at our 6 July stakeholder seminar about the integrity of fuel with high burn up, proposed for use in GDA, following long term storage.

799 There will be requirements for regular maintenance inspections on the fuel condition over the storage period, to maintain confidence that the fuel remains in a suitable condition.

800 Suffolk Coastal District Council (GDA165) noted '*the longer term potential for the degradation of spent fuel'.*

801 The ONR commissioned the National Nuclear Laboratory (NNL) to carry out work to identify mechanisms that could lead to early failure of the fuel cladding or the fuel assembly during storage. This work was reviewed in ONR's Step 4 and the findings were taken into account in our decision.

802 ONR indicate that NNL found that the fuel should remain in a stable state for 100 years such that it is suitable for transport and disposal, providing it is adequately cooled once it is removed from the reactor. The ONR included an assessment finding in GDA that prior to implementing a long term management solution for spent fuel, the licensee will have shown how cool the fuel has to be before it is placed into the long term store.(ONR, 2011c).

803 Stop Hinkley (GDA157) also raised issues for high burn up fuel and length of storage. NDA indicate a reduced timescale for cooling (storage) of high burn up spent fuel of 50 years before disposal, as discussed above.

804 Greenpeace (GDA151) responded to our consultation and noted their support for comments made in the submissions by the NFLA, and BANNG. Their detailed response is available on our website. Greenpeace note that key aspects are unresolved, referring to when and where the longer term storage of spent fuel and encapsulation will take place, and they raise a number of issues about storage and handling of wastes including spent fuel.

11.4.5 Final Disposal and GDF

805 The issue of final disposal of spent fuel and GDF was raised in response to our consultation and during discussions at our GDA stakeholder seminar. These issues and responses are discussed below, however final disposal and GDF is outside the scope of GDA.

806 The Nuclear National Policy Statement (NNPS) confirms that the Government is satisfied that effective arrangements will exist to manage and dispose of the waste that will be produced by new nuclear power stations in the UK. We note that CoRWM have said that the Government must judge whether all the arrangements will exist by the time they are needed (CoRWM, 2010). In the NNPS Government also states that: '*As further evidence of its commitment to the implementation of geological disposal, the Government has reviewed and strengthened the arrangements, to provide oversight of geological disposal implementation and hold the NDA to account as the implementation body responsible for delivery.*' We also note that the Government base case for new build is that a facility for long term storage of high level waste and spent fuel will be available in time to receive the wastes from new reactor build.

807 One of the issues raised at our stakeholder seminar was '*the UK track record of ignoring problem of what to do with spent fuel ie final disposal rather than interim*'.

808 The issue of final disposal of fuel was raised in consultation responses.

809 The Swedish NGO Office for Nuclear Waste Review, MKG (GDA 60). Commented '*I strongly question the new-build of nuclear reactors without having a final solution available for the disposal of the spent nuclear fuel. The NDA appears to try to build some confidence on the possible use of the Swedish/Finnish KBS method in the UK. However, the KBS method, that relies on artificial barriers of copper and clay for long-term safety, is under severe scientific criticism and it is uncertain whether the method will survive the licensing process in Sweden that is to start next year. It appears very unsound to proceed with new build without any other spent fuel strategy than long-term intermediate storage. This mistake has already been done in the 20th century and should not be repeated. Has nothing been learnt from history?*'

810 Nuclear Waste Advisory Associates (NWAA) (GDA133) raised the issue of copper disposal canisters for disposal of spent fuel. We are aware of the recent research findings and ongoing research on copper corrosion in Sweden. It would be for the implementer of a GDF (NDA/RWMD or a successor organisation) in due course to decide whether copper canisters should be used for disposal of the UK's HLW/spent fuel. If copper canisters were to be used, the GDF implementer would need to demonstrate through its environmental safety case that a disposal system including copper canisters would provide the high standards of protection for people and the environment expected in our regulatory guidance, including evidence of the long term durability of the waste container. For the purposes of GDA, however, we note that the conclusions of the disposability assessment NDA RWMD has carried out for UK EPR spent fuel were not dependent on the use of copper and that research into other packaging options and materials will continue.

811 A respondent (GDA92) suggested there was no evidence that the deep geological facility for spent fuel will be constructed in the next 200 years, and be able to accept the spent fuel from the various reactor sites after decommissioning.

812 Issues were raised about the GDF. Suffolk County Council (GDA 72) responded that it '*agrees with the comments made by the Local Government Association's Nuclear Legacy Advisory Forum that… the GDA process should explicitly address the implications of the potential scenarios for the interim management of spent fuel should the Geological Disposal Facility not come forward on the expected timetable*'.

813 West Somerset Council and Sedgemoor District Council (GDA154) noted the potential risks associated with the delay and delivery of the GDF programme, which '*runs the risk of continued need for on-site ILW and spent fuel stores until an ultimate disposal route is established'*. Additionally, at our GDA stakeholder seminar, concerns about the GDF and the fall back for the storage for the lifetime of waste if the GDF falls through were raised.

814 Springfields Site Stakeholder Group (GDA96) responded to the consultation commenting, for both designs, in regard to our preliminary conclusions on spent fuel management '*Both appear to cover the process well, but will depend on agreement being made regarding a Geological Disposal Facility (GDF)*.'

815 The Institution of Mechanical Engineers (GDA145) commented '*The Institution suggests further options for the final disposal of spent fuel (e.g. surface entombment and near surface disposal in overseas dry rock strata) should be considered in addition to the Geological Deep Facility*.'

816 Nuleaf (GDA80) also raised issues about spent fuel disposal and the GDF; '*The UK EPR GDA consultation document does not contain an explicit assumption about whether there is a robust programme for identifying a suitable site for a GDF for*

disposal of new build spent fuel'. Nuleaf discuss the risks and uncertainties that they say may prevent this. '*For example, the capacity of suitable host rock at a preferred site may not be sufficient for new build spent fuel, or the volunteer communities may not agree to the disposal of new build spent fuel. It is arguable that the GDA process should explicitly address the implications of these potential scenarios for the interim management of spent fuel.*'

817 Reference was made by some respondents to the report '*Rock Solid- a scientific review of geological disposal of high level radioactive waste'*. This report was written for Greenpeace International in 2010, and is based on a literature review of papers in scientific journals. It provides an overview of the status of research and scientific evidence regarding the long term underground disposal of highly radioactive wastes. '*Rock Solid*' points to unresolved issues, and scenarios in which a significant release of radioactivity from deep underground disposal could take place, with serious implications for the health and safety of future generations.

818 The comments raised by the Institution of Mechanical Engineers (GDA145) and Nuleaf (GDA80) on GDF and in '*Rock Solid*' on deep underground disposal are outside the scope of GDA.

819 Comments were made about the risk of leakage from a GDF. This is outside the scope of GDA.

11.5 Disposability

820 EDF and AREVA provided a view from the Radioactive Waste Management Directorate (RWMD) of the Nuclear Decommissioning Authority (NDA) (as the UK authoritative source) on the disposability of their proposed arisings of spent fuel.

821 RWMD concluded that compared with legacy waste and existing spent fuel, no new issues arise that challenge the fundamental disposability of the waste and spent fuel expected to arise from operation of the UK EPR.

822 RWMD indicated that the disposal route for RCCAs will need to be clarified. The RWMD assessment indicates they will not represent a major addition to the overall inventory, and that they could be conditioned separately as ILW or disposed of with the rest of the fuel assembly.

823 The activated core components are considered intermediate level waste (ILW), although they generate heat when they are removed from the reactor. These include RCCAs and the stationary core component assemblies. As they are exposed to neutrons in the core, the RCCAs are highly activated by the time they are replaced; they are placed in the spent fuel pool to cool, as is the practice in existing PWR plants.

824 EDF and AREVA provided the Regulators with a critique of the RWMD disposability assessment, considering the impact of RWMD disposability assessment on their plans for conditioning, storing and dispatching the waste to a repository (GDF). The critique raised a number of issues. EDF and AREVA identified that the principal issues were in relation to fuel burn up, assessment inventories, serious fuel cladding failures, interim storage of spent fuel, the use of supplementary data by RWMD, and the chloride impurity assumption.

825 The Regulators requested further information from EDF and AREVA on how they would address the issues raised in their critique and those issues raised by RWMD in their disposability assessment. EDF and AREVA were asked to make a case for the disposability of spent fuel and ILW, which demonstrates the following:

a) How the issues identified in their critique of RWMD's Disposability Assessment will be addressed.

b) How the issues in Appendix B of RWMD's Disposability Assessment will be addressed.

c) How they will manage any risks associated with these issues.

826 EDF and AREVA provided information to the Regulators in February and March 2010. We note in particular that EDF and AREVA have consulted with RWMD specifically on the stages in the Letter of Compliance (LoC) process at which they would expect issues to be addressed. We recognise that, in most cases, these issues will need to be addressed by future operators of UK EPRs, rather than by EDF and AREVA, and we understand that EDF and AREVA have also discussed the timing of resolution of these issues with the potential UK EPR operator.

827 NFLA (GDA82) and NWAA (GDA133) comment in regard to b) above '*neither the issues – nor the industry response is made available to the Public'*. Section 3.3 of our disposability assessment report does not refer to any issues '*that the Environment Agency has raised with the nuclear industry*' – this section refers to the issues RWMD have raised in Appendix B of their disposability assessments, and to a few additional issues raised by EDF and AREVA in their critiques of the disposability assessments. EDF and AREVA have placed the full disposability assessment on their web site, including Appendix B. EDF and AREVA's critique is also published on their web site.

828 EDF and AREVA provided detailed responses in regard to storage and disposability in February and March 2010, and whilst our views were presented in our consultation document, we noted ONR were reviewing this information in its Step 4 assessment.

829 The Regulators requested further supporting evidence from EDF and AREVA to support the case for disposability of waste and spent fuel. EDF and AREVA have developed and submitted a plan to the Regulators for addressing disposability issues and seeking LoC endorsements to support the case for disposability of spent fuel following storage.

830 In general, we consider the plans proposed by EDF and AREVA, outlining how and when they and future licensees will address the outstanding disposability issues, to be adequate at this stage. We will expect these plans to be periodically refined and updated in future to reflect developments. We will expect prospective licensees to make progress on demonstrating disposability at the earliest reasonable opportunities rather than waiting for dates specified in the plan.

831 We continued to work with ONR on this, and this work has informed our final decision. We are satisfied that EDF and AREVA provided a credible plan for long term management of spent fuel. This was sufficient to close out the potential GDA Issue on disposability of spent fuel following longer term interim storage pending disposal (UK EPR-I2).

832 We note that EDF and AREVA have produced a 'mapping document', intended to indicate where the information that will be needed for future Radioactive Waste Management Cases (RWMCs) will come from, and when. EDF and AREVA updated the mapping documents for the RWMCs in January 2011. This document gives us assurance for this stage of the GDA process that RWMCs can be complied at relevant stages in the development of a UK EPR fleet.

833 We identified the following assessment finding:

a) The future operator should provide confidence at the site-specific stage that adequate RWMCs, supported by appropriate stage LoCs and taking due account of necessary storage periods, can be developed for spent fuel on the timescales identified in EDF and AREVA's plan for disposability of spent fuel. (UK EPR AF17)

834 The Regulators requested further information from EDF and AREVA on the encapsulation process for disposal for spent fuel since this was not considered in the RWMD assessment. A final report from EDF and AREVA on the ability to encapsulate spent fuel for disposal was submitted in September 2010. The submission provided a review of international practice, and concluded that encapsulation is a feasible technology.

835 NFLA (GDA82) commented that clarification is needed now on encapsulation. HPA (GDA89) also note it is not clear *'if the repackaging facilities for spent fuel leaving the interim store will be on site, shared between sites or at the GDF*'. CoRWM note that '*the decision on where encapsulation will occur will be taken by reactor operators. It could occur at a central spent fuel store, or, if RWMD agreed at the site of a GDF*.' (CoRWM, 2010).

836 We will need to see evidence that the spent fuel is capable of being packaged and transported safely, and we require the future operators to demonstrate unpackaged spent fuel at a reactor site can safely be turned into packaged spent fuel at a GDF ready for disposal. There is considerable experience internationally to show that packaging could be done safely at the reactor site, the GDF site or a third site if appropriate facilities and operations are put in place. EDF and AREVA considered methods for how they might package spent fuel, and reviewed international experience as part of their response.

837 However, we recognise that EDF and AREVA also need to know other organisations' plans in order to take a considered view of the best option – we are aware, for example, that RWMD are considering the feasibility of a centralised spent fuel packaging facility. We note that RWMD's initial feasibility study for the Nuclear Industry Association identifies and briefly considers options for spent fuel packaging but does not propose a definitive position.

838 We noted in our consultation that ONR was to review this information in its Step 4 assessment. We continued to work closely with ONR on this matter; they reported that information provided by EDF and AREVA on encapsulation of spent fuel is sufficient to show that packaging for disposal should be feasible.

839 An individual respondent (GDA14) provided comment in regard to the Westinghouse design in regard to encapsulation that '*certainly huge amounts of work should not be expended on detailed encapsulation and disposal studies in advance of knowing the geological setting of the GDF*'. This comment is considered applicable to the UK EPR.

840 In their submission, EDF and AREVA provide reasonable proposals for how spent fuel will arise, be managed and disposed of throughout the facility's lifecycle. EDF and AREVA provide information on the fuel composition and characteristics, and expected fuel burn up, and quantities of spent fuel that will arise. Information is provided in the submission and supporting documents on short and long-term management proposals for spent fuel. EDF and AREVA have obtained a view from the RWMD of the NDA on the disposability of the fuel and has provided its opinion/ critique to the Regulators. EDF and AREVA provided sufficient information and evidence to satisfy our requirements for spent fuel management in GDA.

841 ONR through its Step 4 of GDA continued to work with us to review the information supplied by EDF and AREVA as they finalised the information contained in their submissions on long-term storage and disposability. We now have further

information and evidence from EDF and AREVA to support the safe storage and disposal of spent fuel.

842 ONR advised us that the spent fuel can be maintained in a suitable condition during on-site storage such that it will remain acceptable for disposal (ONR, 2011c).

843 We are satisfied that EDF and AREVA provided a credible plan for long term management of spent fuel. This was sufficient to close out the potential GDA Issue on disposability of spent fuel following longer term interim storage pending disposal (UK EPR-I2).

844 We conclude, based on the further evidence provided on EDF and AREVA's management plans for the fuel including storage, that the UK EPR is not expected to produce spent fuel for which there is no foreseeable disposal route.

845 However we will expect EDF and AREVA and potential operators to continue to make progress in consultation with RWMD towards confirming the disposability of spent fuel taking account of necessary periods of storage.

846 We stress, however, that we will expect to see before any UK EPRs begin operation further information from EDF and AREVA on the properties of high burn-up spent fuel following long term storage (particularly in relation to Instant Release Fractions (IRFs)). We recognise that detailed and definitive information may not be available until there is direct operational experience (e.g. for the Interim Stage LoC submission) , but we will expect much earlier than that to see evidence of sufficient progress to provide confidence that any issues are likely to be manageable.

847 Respondents (GDA25, GDA96) confirmed they were satisfied with our conclusions on spent fuel management. Springfields Site Stakeholder Group (GDA96) indicated their support and noted that there would need to be an agreement made on the Geological Disposal Facility (GDF).

848 The Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA67) stated their support for our decision to issue a draft interim statement of design acceptability (iSoDA), noting in regard to spent fuel management '*this is a generic issue for all planned power plants rather than a design specific or site-specific issue*.' They noted the intention for ongoing work between ONR and Environment Agency, as detailed in this document, in evaluating the disposability of long term stored spent fuel. The evaluation by the Regulators is now complete, and we concluded as above that the UK EPR is not expected to produce spent fuel for which there is no foreseeable disposal route.

849 Some respondents disagreed with our findings, suggesting no SoDA be given (GDA 52,133,151,153). One respondent (GDA52) questioned how could we be prepared to issue a draft interim SoDA '*when we don't know if the fuel is disposable'*. The Low Level Radiation and Health Conference (GDA153) suggested no SoDA be given pointing to '*inadequacy of some of the information provided-particularly concerning the disposal of a range of wastes'*. Greenpeace (GDA151) suggested we had postponed '*these outstanding disposability issues to some unspecified time in the future'*. Nuclear Waste Advisory Associates (NWAA) (GDA133) responded noting that we are '*risking authorising the production of yet more nuclear waste for which there is no credible disposal route'*. One of the key objectives of GDA was to ensure no orphan waste was created, for which there was no credible disposal route. We required EDF and AREVA to prepare a waste and spent fuel management strategy for the complete lifecycle, and to provide evidence the waste is disposable, and we are satisfied that the information provided in GDA, including the further information supplied since our consultation, meets our requirements.

850 Suffolk Coastal District Council (GDA165) responded to our consultation to note they have confidence in the technical appraisals undertaken by both the

Environment Agency and the Health and Safety Executive and they support the overall conclusions of the GDA.

851 NNB Genco (GDA106), as a potential future operator of the UK EPR, also noted its support for our conclusions on spent fuel management, and its intent to continue to progress work on long term storage and disposability with RWMD and the Regulators. They noted that '*prospective operators are already working with RWMD to progress key issues, including the minimum duration of interim storage prior to emplacement and optimisation of the GDF design for both legacy and new build spent fuel. We recognise the need for continued close working with the Requesting Party, the Radioactive Waste Management Directorate (RWMD) and the Regulators as the design of the UK GDF develops'*.

852 Horizon (GDA127) responded to our consultation noting '*that the Regulators are continuing to review information about spent fuel disposability and that they have requested further information about long term storage. Horizon accepts that the Department of Energy and Climate Change (DECC) base case for managing and disposing of spent fuel is practical but we are supporting industry work, commissioned by the Nuclear Industry Association (NIA), to optimise the strategy for disposing of both legacy and new-build wastes in the UK, including irradiated fuel. The NDA/RWMD will shortly be publishing its initial feasibility study of the issues'*. This report on work commissioned by NIA was published in 2010 and its findings are discussed in this document.

853 In February 2011, RWMD published its generic Disposal System Safety Case (DSSC, RWMD 2011a). The generic DSSC comprises a suite of reports providing arguments and illustrative, generic safety assessments regarding the transport, operational and environmental safety of a geological disposal system. At this early stage in the site selection process, the DSSC does not relate to any specific site or disposal facility design, hence the term 'generic DSSC'. The published generic DSSC also forms the basis against which future LoC assessments will be undertaken.

854 The generic DSSC supersedes the disposal concepts and assessments used as the basis for the previously published GDA Disposability Assessments. In order to establish the continuing validity of the published conclusions of the GDA Disposability Assessments, RWMD revisited the GDA Disposability to determine whether the generic DSSC materially affects the findings published in 2009. The outcome of that review was published as a Technical Note (RWMD 2011b) and states:

"*Overall, the changes in concept, assessment methodology and assumptions regarding parameter values have only minor impacts on the findings of the original GDA Disposability Assessments. The review therefore confirms that there are no new issues arising from the generic DSSC that would challenge the fundamental disposability of the wastes and spent fuel expected to arise from operation of the AP1000 and EPR. This conclusion is supported by the similarity of the wastes to those expected to arise from the existing PWR at Sizewell B, which are included in the generic DSSC Baseline Inventory and have been found to be acceptable*."

855 The GDA Disposability Assessments also estimated the cooling times necessary to allow sufficient radioactive decay that the heat output of packaged spent fuel would be consistent with the temperature limit applied by RWMD. These estimates have not been revised as the temperature limit is unchanged in the generic DSSC.

12 Monitoring of radioactive disposals

12.1 Conclusions

856 Our conclusions are unchanged since our consultation, however, we have reworded our assessment finding.

857 **We are unable to conclude that the UK EPR utilises the best available techniques to measure and assess radioactive disposals.**

858 As part of our assessment, we identified the following assessment finding:

a) Future operators shall provide:

   i) during the detailed design phase, the location and arrangement of sampling and continuous monitoring facilities for gaseous and aqueous wastes supported by an assessment that these represent BAT and will provide representative sampling and monitoring;

   ii) during the detailed design phase and before final equipment selection, the details of equipment and techniques to be used for analysis of gaseous, aqueous and solid wastes supported by an assessment that these represent BAT for monitoring. (UK EPR-AF16)

12.2 Background

859 We expect the design to use the best available techniques to measure and assess discharges of radioactive waste to the environment. This will enable any operational UK EPR to:

a) confirm that discharges are as predicted by the designer;

b) assess compliance with limits;

c) provide good quality data for dose assessments.

860 A number of consultation responses were received in regard to monitoring of radioactive disposals which are discussed in the relevant parts of this chapter or at the end of this chapter. No questions on monitoring of radioactive disposals were raised at our 6 July GDA stakeholder seminar.

12.3 Monitoring of gaseous disposals

861 We summarise below the information presented in EDF and AREVA's submission on the monitoring of gaseous disposals. We assessed all this information and used the GDA process of ROs and TQs to query and expand information where necessary. The conclusions of our assessment are provided at the end of this sub-section.

862 Measures for monitoring discharges are described in chapter 7 of the PCER and in document UKEPR-0007-001 '*Monitoring of liquid and gaseous discharges: Prospective arrangements for the UK EPR*'. BAT is described in chapter 8 of the PCER.

863 Activity concentrations will be determined for tritium, noble gases, iodine and other activation or fission products and carbon-14. Emission rates will be determined using an average flow rate via the stack for the discharge period. EDF and AREVA state that the measuring techniques correspond to BAT with some justification given in PCERsc8.4. Sampling procedures appear to be reasonable, but the submission is lacking information on sampling locations. EDF and AREVA understand the need for isokinetic sampling and stated arrangements will be implemented to meet ISO 2889:1975. However, we will expect arrangements to meet the more recent standard ISO 2889:2010 and EN15259:2007. They are committed to determining detection limits, decision thresholds and expression of results in compliance with EU Commission Recommendation 2004/2/Euratom, however the proposed krypton-85 and carbon-14 limits of detection would not meet required levels (PCERsc8.4 Table 1). The future operator will need to demonstrate that they meet these requirements. The UK EPR gaseous effluent treatment system presents some major differences to that currently in place in existing stations. As such, it is expected that some of the monitoring activities may be different in the UK EPR.

864 The detailed design of the main stack and the associated monitoring arrangements for the reference EPR are not yet finalised. Additionally, EDF and AREVA state that the height of the stack will be site-specific. Further site-specific verification will be needed on the sample probe locations and compliance of the purchase specifications for devices to meet guidance and MCERTs requirements. (PCERsc7.3s1.1.2)

865 EDF and AREVA claim that: (PCERsc7.3s1.1.2)

a) there is redundancy built into the systems which would allow for continuity of monitoring and provision of independent samples;

b) installation of sampling and monitoring equipment would take account of engineering rules, regarding space for monitoring operations and maintenance.

866 We have assessed the information EDF and AREVA provided on the UK EPR design for the determination of gaseous discharges against the requirements of M1 (Environment Agency, 2010a) and M11 (Environment Agency, 1999a) and other best practice for monitoring.

867 **We have concluded that:**

a) **BAT has not been comprehensively demonstrated for the monitoring on the UK EPR gaseous effluent systems.**

b) **We could not make an assessment on the suitability of the sampling lines, EDF and AREVA say that arrangements may be site-specific. We require sample lines to be as short and direct as possible.**

c) **Evidence has not been provided to back up the statements about how representative samples would be achieved, therefore, we could not assess whether monitoring locations being planned are appropriate.**

12.4 Monitoring of aqueous disposals

868 We summarise below the information presented in EDF and AREVA's submission on the monitoring of aqueous disposals. We assessed all this information and used the GDA process of ROs and TQs to query and expand information where necessary. The conclusions of our assessment are provided at the end of this sub-section.

869 Measures for monitoring discharges are described in chapter 7 of the PCER and in document UKEPR-0007-001 '*Monitoring of liquid and gaseous discharges: Prospective arrangements for the UK EPR'*. BAT is described in chapter 8 of the PCER.

870 Pre-discharge screens are carried out on a sample from each tank for tritium, to check the absence of gross alpha activity, gross beta and gross gamma. Further checks are then carried out on a sample after discharge either taken from the tank before discharge or an aliquot sample representative of all the discharges from the tanks over one period. Activity concentrations will be determined for tritium, iodine radionuclides and other activation or fission products and carbon-14 and activity discharged by multiplying by volume discharged. EDF and AREVA state that their measuring techniques correspond to BAT with some justification given in PCERsc8.4. No details have been provided on how the discharge volume is measured and samples taken, but EDF and AREVA demonstrate that they understand the need for homogenous representative samples. They are committed to determining detection limits, decision thresholds and expression of results in compliance with EU Commission Recommendation 2004/2/Euratom, however the proposed tritium limit of detection (LoD) would not meet the required level (PCERsc8.4 Table 2).

871 EDF and AREVA are proposing not to monitor for strontium-90 and they are also not proposing to seek authorisation for alpha emitters (plutonium-239, plutonium-240 and americium-241). However, gross alpha activity will be monitored.

872 Ingleby Barwick Town Council (GDA38) provided the following response to our consultation: '*I am surprised at your monitoring of Strontium 90 and Plutonium 239 and 240, especially in the early life of the reactor.*' We are not expecting routine monitoring of strontium-90, plutonium-239 and plutonium-240 but this may be a requirement for periodic measurement.

873 EDF and AREVA state that separate flow proportional sampling will be arranged as required by the Regulator. (PCERsc7.3s2.1.3)

874 EDF and AREVA state that they will take into account MCERTS, but they have not given any information as to how and if they have considered whether appropriate instrumentation (for example, flow meters) is available. (PCERsc7.3s2.1.4.1)

875 We expect as BAT, that sampling and monitoring equipment to be protected from the weather and interference by unauthorised personnel and for analysis to achieve ISO17025 (BSi, 2005) and MCERTS accreditation. EDF and AREVA state that sampling is to be carried out in the pumping station which is in a controlled area and that they recognise the need for the laboratory to be accredited. (PCERsc7.3s2.2.3)

876 We have assessed the information provided by EDF and AREVA on the UK EPR design for the determination of aqueous discharges against the requirements of M12 (Environment Agency, 1999b) and other best practice for monitoring.

877 **We have concluded that:**

a) **we were unable to assess whether monitoring locations being planned are appropriate as there was insufficient information in the submission.**

12.5 Monitoring of solid disposals

878 EDF and AREVA have provided limited information on monitoring of solid waste.

12.6 Monitoring of radioactive disposals – review of consultation responses

879 A individual respondent (GDA25) provided the following response to our consultation: '*I believe that a thorough and open system of monitoring and reporting the disposal of radioactive waste is very desirable to instil confidence in residents around the site and over a wider area*'. Maldon Town Council (GDA51) said: '*We note that no assessment has been carried out to date. UK EPR not provided any detailed information on solid waste*.' West Somerset Council and Sedgemoor District Council (GDA154) said: '*We are concerned that an effective monitoring, management and intervention programme is established to consider the potential cumulative effects on the surrounding receptors and ensure that findings are clearly and concisely communicated to the local communities surrounding reactor sites*.' The Institution of Mechanical Engineers (GDA145) said that monitoring equipment is vital to reassure the public and gain acceptance of future stations. Stop Hinkley (GDA157) are concerned that insufficient information has been supplied by EDF and AREVA on sampling lines and achieving representative samples.

880 Ingleby Barwick Town Council (GDA38) provided the following response to our consultation: '*Sampling must be conducted on a regular time basis and procedures adopted to see that any problems are tackled on a planned basis.*' We agree with this comment and we will assess this at the commissioning phase.

881 NNB Genco (GDA106) provided the following response: '*We support the Environment Agency's conclusion that monitoring of radioactive disposals is an essential element in demonstrating good environmental performance and effective application of BAT to the design, construction, commissioning and operation of UK EPR facilities. We recognise the obligation on prospective operators, including NNB GenCo, to ensure that BAT is being applied. We also recognise that radiation metrology is a constantly advancing field. The methods used must clearly represent BAT, which for example will require proportional sampling. But given the timescale on which UK EPRs will actually be commissioned and radioactive disposals will therefore begin, it is important to ensure that decisions on equipment and techniques are not made prematurely. This would foreclose the benefits from future developments. Thus it is important that prospective operators remain able to make the right decisions on appropriate monitoring techniques at the right time. These could also then comply with, and reflect developments in, the latest guidance and standards (such as the Environment Agency's Monitoring Certification Scheme MCERTS and its planned extension).'*

882 Additionally, Horizon Nuclear Power (GDA127) provided the following response: '*We note the EA's conclusion and recognise that the monitoring of radioactive disposals will be addressed in more detail during site-specific permitting. We would, however, also note that information on monitoring techniques provided during site-specific permitting will need to be appropriate to the development of the design at the time of the application. It is Horizon's view that initial information will relate more to principles and strategy. As the programme develops, and we get closer to construction of the relevant parts of the plant, further details on specific techniques and equipment will become available*.'

883 We require information at an early stage to ensure BAT has been considered so that the UK EPR early design does not rule out the most suitable options for monitoring. For example, from current guidance on sampling lines, there are requirements that need to be met (which will not be subject to technological change) and these need to be appropriate from the outset (for example; short sampling lines, isokinetic flow, access to sampling ports). We agree that individual

instrumentation is advancing and would not expect this to be specified at this early stage.

884 Sellafield Ltd (GDA126) provided the following response: '*The EA could not conclude that the proposal utilises BAT. We would not see this as a major difficulty given that the technological needs for sampling and for sample analysis are so well understood.*' Sampling is important at the design stage as a plant needs to be constructed in such a way as not to foreclose on appropriate techniques. The fact that the needs are universally understood does not mean they will be incorporated.

885 Several respondents, including; an individual respondent (GDA84), the Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA67),Springfields Site Stakeholder Group (GDA96), Committee on Medical Aspects of Radiation (GDA129), Stop Hinkley (GDA157), and the Institution of Mechanical Engineers (GDA145) said that they were satisfied with our conclusions on monitoring of radioactive disposals and recognised our requirement for more information.

13 Impact of radioactive discharges

13.1 Conclusions

886 Our conclusions are unchanged since our consultation, however, we have reworded them to be more concise.

887 **We conclude that:**

a) **EDF and AREVA's generic site parameters and their values, which define their generic site, are appropriate to use in their assessment of radiological impact at the GDA stage;**

b) **EDF and AREVA have made an adequate assessment of the impact of the discharges, which assumes that the UK EPR is located at a coastal location. The estimates of dose to members of the public are well below the UK constraint for any single new source of 300 μSv y^{-1} and also below the dose constraint proposed by the Health Protection Agency (HPA, 2009) who recommend that the UK Government select a value for the constraint for members of the public from new nuclear power stations to be below 150 μSv y^{-1};**

c) **at the GDA stage the maximum predicted gaseous releases and aqueous discharges for a UK EPR at the generic site are unlikely to pose a risk to non-human species. We consider that the assessment is suitably conservative.**

888 We assessed the information EDF and AREVA provided for the UK EPR relating to the impact on members of the public and non-humans as a result of the disposal of aqueous and gaseous radioactive waste by discharging it to the environment. We also undertook our own dose assessment based on the limits we set out in chapters 8 and 9 of this document.

889 Future operators will need to provide a detailed site-specific impact assessment for each site proposed. The site-specific assessment will need to be based on the actual environmental characteristics of the proposed site to demonstrate that doses to members of the public from the UK EPR at the proposed site will be as low as reasonably achievable (ALARA) and below relevant dose constraint and dose limits. A respondent, the Health Protection Agency (GDA88), agreed that detailed site-specific assessments of the potential impacts of discharges to the environment will be required at the permit application stage.

13.1.1 Recent studies on health risks near nuclear plants and risk factors from radionuclides.

890 We have received comments from several respondents about two recent studies and reports on health risks near nuclear sites and from tritium and whether these have been considered.

891 Our dose assessments take into account health risks arising from exposure to radiation using UK dose to risk factors that have been recommended by the Health Protection Agency (HPA). The UK factors are based on those recommended by the International Commission on Radiation Protection (ICRP) and form part of a

wider radiation protection framework (ICRP-60 and ICRP-103) and enacted into legislation through the Basic Safety Standards Directive (96/29/EURATOM) and in the UK through the Ionizing Radiation Regulations 1999, and the Environmental Permitting Regulations 2010. The risks from doses are reflected in the dose limits and dose constraints set in this legislation.

892 In 2007 a study had been published of leukaemia near nuclear sites in Germany – the so called KiKK study (Spix et al 2008, Kaatsch et al 2008). A separate study was also undertaken into risk factors specifically related to tritium (AGIR 2007).

893 The HPA (Mobbs et al 2010) have stated that the KiKK study was reviewed by the German Commission on radiation protection who concluded that the design of the KiKK study was unsuitable for establishing relationships between leukaemia and exposure to radiation from nuclear power plants. This is because the natural radiation exposure within the study area and its fluctuations are greater by several orders of magnitude than the radiation exposure from the nuclear power plants themselves. Similar UK and French data have subsequently been analysed for any trend with distance and do not show higher levels of leukaemia close to power stations.

894 The Committee on Medical Aspects of Radiation in the Environment (COMARE) have published an in-depth review of the available evidence from several countries operating nuclear power programmes, including Britain and Germany (COMARE 2011). The review included a current analysis for risk of childhood leukaemia in children under five years of age living within five km of a nuclear power plant (NPP) in Britain. COMARE found no reason to change its previous advice that there is no evidence of an increased risk of childhood leukaemia and other cancers in the vicinity of Nuclear Power Plants (NPPs) due to radiation effects. COMARE recommended, however, that the Government keeps a watching brief in this area. Their previous recommendation to continue initiatives into leukaemia and cancer research, to identify the causative mechanisms for childhood leukaemia has been re-iterated. They strongly recommend that there is no reduction in the surveillance, of the environment and the health of the population. This would include environmental measurements of radioactivity which gives an independent check on reported and measured discharges from British nuclear installations, with a particular focus on carbon-14.

895 We formally sought advice from the HPA to confirm if our dose factors or methodology should be reviewed as a result of the Advisory Group on Ionizing Radiation (AGIR, 2007) report on tritium. HPA have advised us that the current radiation protection system remains appropriate, the current risk factors are valid and that we should continue to use the dose coefficients published by ICRP in our regulatory decision-making. HPA restated this position with respect to tritium and the AGIR in their response to the 2007 recommendations of ICRP.

896 The HPA has recently recommended a revised dose constraint of 150 µSv y^{-1} (0.15 mSv y^{-1}) for use at the planning stage of new nuclear facilities (HPA, 2009).

897 For our regulation we continue to apply the dose factors published by ICRP (ICRP, 1996) and compare the calculated doses with the legal dose limits and dose constraints (EPR 10) and have taken into account the revised dose constraint recommended by the HPA. This constraint has not so far been adopted into UK Government policy requirements.

13.1.2 Assessment of doses by the requesting party EDF and AREVA

898 EDF and AREVA carried out a three-stage assessment of the impact of their expected discharges on the public. They started with a simple and cautious assessment (stage 1), a more refined assessment (stage 2) and a detailed assessment (stage 3). For the stage 3 assessment, their estimate of doses was 26 µSv y^{-1}. This dose was from the operation of a single UK EPR, with discharges at the annual limits specified above. This approach is consistent with the principles that have been laid down for dose assessments. (Environment Agency et al 2002)

899 We repeated the assessments provided by the requesting party and were able to verify all stages of the assessment (see below).

900 EDF and AREVA's estimate of dose is well below the UK constraint for any single new source of 300 µSv y^{-1}. The assessment of dose is also below the dose constraint proposed by the Health Protection Agency (HPA, 2009) from new nuclear power stations of 150 µSv y^{-1}.

901 We made two assessments of dose; a stage 2 assessment to verify the EDF and AREVA assessment and a more detailed stage 3 assessment. Our stage 3 assessment was similar to that of EDF and AREVA but with some different assumptions about food production and human habits. Our assessment of the doses from the UK EPR at stage 2 was 63 µSv y^{-1} and at stage 3 was 31 µSv y^{-1}.

902 EDF and AREVA also made an assessment of radiation dose rates to plants and animals on land near an operating UK EPR and also in the sea affected by discharges. They predict the highest dose rates to be:

a) 0.003 µGy h^{-1} for a terrestrial organism (a mammal);

b) 0.01 µGy h^{-1} for a marine organism (a polychaete worm).

903 We have also made an assessment of radiation dose rates to plants and animals near an operating UK EPR. We predict the highest dose rates to be:

a) 0.1 µGy h^{-1} for a terrestrial organism (a bird egg);

b) 0.02 µGy h^{-1} for a marine organism (a mammal and reptile).

904 These dose-rates are well below 40 µGy h^{-1} which is the value below which we consider that there will be no adverse effect on the integrity of a conservation site (Environment Agency, 2009d).

13.2 Verification of assessments of impact

905 EDF and AREVA have made an assessment of the impact of the discharges of radioactivity from the UK EPR to the environment. We have reviewed their assessment in detail. Our review involved two main processes.

906 The requesting party's initial assessment was based on the methodology in the Environment Agency system (Environment Agency, 2006). Their more detailed assessment of exposure of people used the methodology described in EC publication RP-72 (Simmonds et al 1995) and as implemented in PC CREAM-98 by the HPA.

907 Our first activity was to verify the assessment EDF and AREVA provided. The verification was aimed to reproduce the assessment made by EDF and AREVA, adopting their model and input data. As noted above we were able to reproduce their assessment. Our second activity was to carry out our own assessment of the impacts using best practice, models and assumptions. We used the method set out

in the EC publication RP-72 and the PC CREAM-98 system. This was augmented by additional information on the effect of buildings on the dispersion of releases to atmosphere. These are summarised in Table 13.1 below. We compared the outputs and approach from our own assessment with those of EDF and AREVA – the outcome at Stage 3 was very similar. We followed up any significant discrepancies with EDF and AREVA. These processes helped us to be sure that the assessment of impacts on people and the environment were correct and valid.

908 We received several comments that the process and the assessments made by the RP and by us seemed rigorous and thorough and gave confidence that the outcomes are sound. Respondents agreed that our provisional conclusions from the dose assessment are sound. One respondent, the Institution of Mechanical Engineers (GDA145), agreed '*with the consultation document conclusions. We feel this was a good section demonstrating that the plant will meet all requirements by a good margin and reassuring to see such good agreement between the EDF and AREVA data and the regulator's independently calculated data. The Institution feels assured that EDF & AREVA have assessed fully the impact of radioactive discharges and all dose-rates are well below 40 µGy* h^{-1}'.

909 In 2009 the HPA updated their dose assessment methodology and provided a revised implementation of the method in PC CREAM-08. HPA advised in their comments that the newer implementation in PC-CREAM-08 would give similar results to PC-CREAM-98 but recommend adoption of PC-CREAM-08 in future. Therefore when we make our own site-specific assessment PC-CREAM-08 will be used.

Table 13.1 summary of assessment outputs from the EDF and AREVA assessment of the UK EPR and our verification for maximum discharges

Assessment	EDF and AREVA calculated dose µSv y^{-1}	Verification of EDF and AREVA assessment	Our calculated dose using our assumptions µSv y^{-1}
Stage 1	138+	V	138+
Stage 2	63+	V	63+
Stage 3	26*	V	31*
Short duration release to atmosphere	1.5**	VC	1.5**

* Dose to the representative person including direct radiation

\+ Sum of doses to the groups most exposed to gaseous and aqueous discharges and direct radiation

** Units are µSv

V – verified – able to reproduce their assessment exactly

VC – validated by comparison between our assessment and EDF and AREVA.

13.3 Generic site concept

910 At present, there are no specific sites for which detailed site-specific assessment can be made. In the generic design assessment (GDA) stage, ahead of an application to build and operate a UK EPR at a particular site, we have requested that the suppliers of the UK EPR design (EDF and AREVA) to make an assessment to inform us about the potential impact from an operating UK EPR. This assessment is based on available information for the design. To make sure that the assessment is not unrealistic, we required EDF and AREVA to consider a 'generic site'. The characteristics of the generic site should be appropriate to sites in the UK where nuclear power stations might be built and will define the 'envelope' of applicability of any statement of design acceptability that we might issue.

911 We have asked EDF and AREVA to identify the key factors that will affect the doses received and take them into account when establishing the characteristics of the generic site. The key characteristics that are:

a) weather and other parameters affecting gaseous dispersion and deposition;

b) hydrographic and other parameters affecting aqueous dispersion;

c) location of nearest food production, how close people might reasonably live to the site, the location of sensitive habitats and species;

d) food consumption rates – in particular locally produced food and other human habits data.

912 EDF and AREVA have provided information on generic site characteristics. (PCER Chapter 10). They have derived their UK EPR generic site characteristics assuming the UK EPR will be located at a coastal site. They have chosen these characteristics to provide a good geographic representation and represent typical data for sites where potentially a new UK EPR reactor might be located.

13.3.1 EDF and AREVA generic site characteristics and exposed groups

913 EDF and AREVA's UK EPR generic site characteristics include data on:

a) **Human population – Exposed population groups** – for dose assessment purposes, EDF and AREVA have considered five exposure groups:

   i) Two locally resident farming families were assessed who had exposure pathways associated with atmospheric releases from the UK EPR. The first local resident farming family who live 500 m from the aerial discharge point. They spend most of their time at home, some of which is spent outdoors (50% indoors and 50% outdoors for adults). They eat terrestrial food from local sources (vegetables, milk and meat), which are 500 m from the aerial discharge point. The second local resident family is assumed to eat locally caught fish and shellfish in addition to terrestrial sourced food.

   ii) Two fisherman families selected to represent the exposure pathways associated with discharges from the UK EPR to the coastal environment. The first fisherman family are assumed to spend time on intertidal sediments in the area and consume high levels of locally caught fish and shellfish. The second fisherman family is assumed to spend time on sediments, eat fish and shellfish and as well as smaller amounts of terrestrial foodstuffs from local sources up to 500 m from the aerial discharge point. These groups live far enough from the site not to be exposed to direct radiation from atmospheric releases.

iii) The fifth local resident assessed is a combination of the first group (local farming family eating terrestrial foodstuffs) and the third group) fisherman family eating high levels of locally caught fish and shellfish).

b) **Habits data**- which includes things such as food consumption rates, breathing rates and occupancy rates for three age groups (1 year old infant, 10 year old child and adult). At existing nuclear sites we have collected habits data to use in our impact assessments. However, for the generic sites, where no site-specific data is available, generic habits data can be used. This data is used to define habits for the exposure groups considered in the assessment. Generic habit data derived from UK national surveys is published in recognised sources such as NRPB-W41. (PCERsc11.1 Tables 9 and 12). Generic habits normally lead to greater exposure than site-specific habits, resulting in higher predicted doses than may be expected for a site-specific assessment.

914 **Non-human species** – It is assumed that European and UK protected species may be present including birds, terrestrial mammals, reptiles and amphibians, marine mammals and fish, invertebrates and flora. EDF and AREVA have assumed that all reference organisms specified in the ERICA (see chapter 13.9 below) integrated approach are present. Using reference organisms with defined anatomical and physiological properties and habits to represent typical organisms in the ecosystem is an accepted practice in assessing the impact on non-human species. (PCERsc10.4 Table 2).

915 **Meteorology**– EDF and AREVA have specified meteorological data for the generic site. They have described as a typical coastal UK location with a uniform windrose and 70 per cent Pasquill category D. Data on atmospheric washout and deposition coefficients have been used which are consistent with data published in recognised sources such as RP72. (PCERsc11.1 Table 7)

916 **Terrestrial environment** – EDF and AREVA have specified the generic terrestrial environment in terms of the parameters that need to be defined for prospective radiological impact assessment purposes. This is a coastal site in a rural agricultural area. More detailed information on the terrestrial environment will be made available at the site-specific stage. (PCERsc11.1 Table 7)

917 **Coastal environment** – EDF and AREVA have specified the local waters generically by adopting restrictive values for parameters such as volumetric flow rate, depth, coastline length, sediment load, rate and density, bioturbation and diffusion rate for potential sites where the UK EPR might be located. A number of coastal and estuarine sensitive habitats are assumed likely to be present near the generic site. (PCERsc10.4 Table 1 and sc11.1 Table 7)

918 EDF and AREVA use the UK EPR generic site characteristics in their assessment of the potential radiological impact of the UK EPR on members of the public and non-human species.

13.3.2 Our view of the EDF and AREVA generic site characteristics

919 We have reviewed the EDF and AREVA generic site characteristics. We believe that they are justified and reasonable and represent a conservative approach, while also being realistic. We recognise that a detailed site-specific assessment of the radiological impact from the UK EPR will be required for any site where the UK EPR is proposed and, therefore, site-specific data will be required for any site at which a UK EPR reactor may be located.

920 **We conclude that EDF and AREVA's generic site parameters and their values, which define their generic site, are appropriate to use in their assessment of radiological impact at the GDA stage.**

13.4 Our requirements for the assessment of doses to people

921 We have required EDF and AREVA to make an assessment of doses to the representative person. This assessment should use the generic site characteristics, together with agreed or expected levels of discharges, and suitable models to predict the behaviour and concentrations of radionuclides in the environment once they have been discharged. We require allowance for build up in the environment from discharges continuing for 50 years. A reference modelling system is the EC system described in an EC publication number RP-72 and implemented by the HPA in a computer code PC CREAM 98. EDF and AREVA adopted this system for their stage 3 assessment.

922 Doses to members of the public are calculated taking account of the predicted levels of radionuclides in the environment and the habits of members of the public near the site. Those members of the public who are estimated to receive the highest dose overall (from gaseous and aqueous discharges and direct radiation) are described as the 'representative person'. The dose to the representative person is then compared with the dose constraint and dose limit. Doses to members of the public from direct radiation originating from within the site boundary are regulated by ONR. However, for the purposes of comparing doses to the dose constraints, we have estimated doses from direct radiation based on data for direct radiation doses from Sizewell B in 2007 (Environment Agency et al, 2008). ONR will be making an assessment of direct radiation dose as part of its work in GDA Step 4.

923 The assessment approach is designed to make sure that provided the dose to the representative person is below these dose criteria, doses to the public near the site will also be less than the dose criteria. We may also consider doses from aqueous discharges or gaseous discharges separately. Where a separate assessment is made for different types of discharges, the term '*representative person most exposed to*' is used. Doses from the separate assessments may be added together to provide an estimate of total dose from the reactor. However, this addition is likely to give rise to an over-estimate of dose. This is because it is unlikely that any person would have both sets of habits that would lead to most exposure to various types of discharges at the same time. Therefore, the dose to the representative person is calculated using a method that makes realistic combinations of exposures and habits.

924 EDF and AREVA provide information on their assessment of doses to the public in their submission. (PCERsc11.1).

13.4.1 EDF and AREVA assessment approach

925 EDF and AREVA carried out a three-staged approach to their assessment. The first two stages followed our initial radiological assessment methodology (Environment Agency, 2006), which allows a conservative assessment of doses to members of the public from discharges of gaseous and aqueous radioactive waste.

a) Stage 1 is normally a conservative or bounding assessment that can be used as a screening assessment to identify if a more detailed dose assessment is required. EDF and AREVA used our published dose per unit release factors given in our initial radiological assessment methodology. For gaseous radioactive waste discharges, EDF and AREVA assumed an effective release height at ground level for the stage 1 assessment, which is likely to be the worst case. For aqueous radioactive waste, it was assumed discharges were made into local coastal waters, which then mix with water from elsewhere along the coast by volumetric exchange. The volumetric exchange rate used was $100m^3s^{-1,}$ which is the conservative value recommended in our initial radiological assessment methodology.

b) Stage 2 is a more refined assessment using more realistic key parameters such as stack height and aqueous dispersion factors. EDF and AREVA used our published dose per unit release factors in a more realistic way. For gaseous discharges, the effective release height was assumed to be 20 m, which EDF and AREVA consider to be more realistic. The UK EPR stack protrudes a few metres above the reactor building, which is likely to be around 60 m high. A building of this height produces a wake effect which will tend to pull atmospheric releases made near the top down towards the ground relatively quickly than if the release is by a stack in isolation and away from nearby buildings. This is effect is modelled by calculation of effective stack height, which is normally one third of the actual height. Therefore gaseous releases just above a building of 60m can be modelled by an effective release height of 20 m. For aqueous discharges, the volumetric exchange rate along the coast was taken to be 130 $m^3 s^{-1}$. This is the lowest exchange rate (worst case) at four locations around England and Wales chosen by EDF and AREVA to represent sites where potentially a new UK EPR reactor might be located.

926 For both stage 1 and 2 our methodology calculates doses to the most exposed members of the public for gaseous and aqueous radioactive waste discharges. Doses to the most exposed members of the public were calculated for three age groups (infant, child and adult) for each radionuclide in the discharge. The doses to the age group, which resulted in the highest dose to the most exposed member of the public for each radionuclide, have been used to calculate the total dose to the most exposed members of the public.

927 EDF and AREVA also estimated doses from direct radiation from the UK EPR in order to predict the dose to the representative person.

928 Stage 3 is a more detailed assessment and is usually carried out where stage 2 outputs are above dose criteria. A stage 3 assessment may also be carried out where additional assurances or more detail is needed about predicted doses.

929 EDF and AREVA carried out stage 3 of the assessment using the PC CREAM 98 model assessment system. PC CREAM 98 is an EC system for modelling and assessing the transfer of radionuclides in the environment and making estimates of doses to members of the public. The assessment assumed continuous uniform releases for 50 years at the maximum annual discharge levels for both aqueous and gaseous radioactive waste. The stage 3 assessment takes into account the potential for exposure of members of the public by a combination of internal and external pathways. EDF and AREVA have estimated the total dose to a representative person who is a member of the local fishing community and who also simultaneously is a farmer living 500 m from the sites who is exposed to atmospheric releases and consumes locally produced food, two food types at high rates and all other food types at average rates. This person also spends time close enough to the site to receive a dose from direct radiation.

930 We consider the approach and assumptions EDF and AREVA made in their dose assessment to be reasonable. For the stage 3 assessment, we note some minor divergences from standard practice. However, we do not consider these will affect the results of EDF and AREVA's dose assessment significantly. The divergences in approach relate to the assumed location of the nearest habitation, inhalation rates for indoors and outdoors and certain marine dispersion parameters. Further detail can be found in our assessment report IMAS/TR/2010/05 (Independent Dose Assessment).

13.4.2 EDF and AREVA's assessment results

931 Table 13.2 shows the doses EDF and AREVA predicted.

Table 13.2: EDF and AREVA predicted doses for the UK EPR design for maximum expected annual discharges.

Pathway	Doses to the public μSv y^{-1}		
	Stage 1	Stage 2	Stage 3
Aqueous discharges	60	46	17
Gaseous discharges	73	11	4
Direct radiation	6	6	5
Total dose	**138**	**63**	**26**
Short duration release to atmosphere+	N/A	N/A	1.5+**

\+ Assuming 1 month's worth of discharge occurs over 24 hours.

** Units are μSv

932 EDF and AREVA's stage 3 assessment resulted in estimated doses to the representative person of the public of 26 μSv y^{-1} to an adult (Table 13.2). Doses to other age groups were 12 μSv y^{-1} to a child and 11 μSv y^{-1} to an infant.

933 The highest contribution to dose was from consuming carbon-14 in fish resulting from aqueous discharges.

934 From time to time, processes on site may result in additional discharges to atmosphere. These include de-fuelling and coolant purges. The discharges can range from 30 minutes to several hours. EDF and AREVA have made an assessment of a short duration release – assuming one month's discharge is released over 24 hours. This a conservative assumption in that it is likely to be an overestimate of the discharge made over such a short timescale. These resulted in estimated doses from a UK EPR to the representative person of the public of 1.5 μSv to an infant. Doses to adults and children are estimated to be 0.9 μSv.

935 One respondent commented that the simple addition of doses from each release pathway and direct radiation in Table 13.2 could be misleading. This is because the different pathways will have different most exposed groups and doses cannot

simply be added. We note that because this is not a site-specific assessment we have no site-specific habit data which would allow us to adopt the profiling method for establishing habit combinations for prospective dose assessments (NDAWG 2009). However the simple addition of doses is likely to overestimate rather than underestimate doses and so is informative. We will make site-specific assessments which will make use of site-specific habit data and appropriate assessment methods where appropriate.

936 **We conclude that all the doses EDF and AREVA assessed are below the dose constraint for members of the public of 300 µSv y^{-1} and the dose constraint recommended by HPA for new build of 150 µSv y^{-1}.**

13.4.3 Our verification of the EDF and AREVA assessment results

937 We were able to repeat all three stages of the EDF and AREVA dose assessment.

938 We carried out our own dose assessment, assuming discharges are made at the maximum annual discharges. For this, we used the PC CREAM 98 model and standards and practices used by the Environment Agency for regulation under RSA93. The assessment commenced in 2008 before a later model of PC CREAM was available and before EPR 10.

939 Our stage 3 assessment showed the highest estimated doses from an EPR is to an adult representative person of 31 µSv y^{-1}, who is most exposed to aqueous discharges (Table 13.3). We have also proposed some annual limits on discharges for the UK EPR and assessed the potential impact at these limits. The assessed impact is broadly the same as that predicted by EDF and AREVA. Our assessment estimates the dose to be 30 µSv y^{-1} and the slight difference is due to rounding of the numerical results in the calculations.

940 The highest doses are from aqueous discharges and the highest contribution was from carbon-14 in fish.

Table 13.3 Summary of our assessed doses to representative person at stage 3 from the UK EPR design at maximum expected annual discharges and our proposed limits.

Pathway	Doses to the public µSv y^{-1}	
	Maximum expected discharges	Our proposed limits
Aqueous discharges	28	28
Gaseous discharges	3	3
Direct radiation+	0	0
Total dose	**31**	**30***

+ The representative person belongs to a group that is most exposed to aqueous discharges and receives no dose from direct radiation

* Rounded figure

13.5 Source dose constraint

941 There is a dose constraint (HMSO, 2010[11]) for the maximum dose to people that may result from discharges from a new single source (for example, a new power station). The constraint is 300 μSv y^{-1} and it applies to the dose from proposed discharges and direct radiation.

942 As set out above, our assessment shows that, for the UK EPR, the sum of doses to the representative person from the maximum expected discharges and direct radiation is 31 μSv y^{-1} and is below the source dose constraint. At our proposed limits, the sum of doses to the representative person is 30 μSv y^{-1}, which is also below the source dose constraint.

943 **We conclude that the sum of doses to the representative person is below the source dose constraint.**

13.6 Site dose constraint

944 There is also a dose constraint (HMSO, 2010) for the maximum dose to people that may result from discharges from a site as a whole. The constraint is 500 μSv y^{-1} and it applies to the total dose from the discharges (direct radiation is not included) from all sources at a single location, including discharges from immediately adjacent sites.

945 All the sites listed in the Nuclear National Policy Statement (DECC, 2011a) as potentially suitable for a new nuclear power station are adjacent to existing nuclear power stations. In GDA, the specific site at which a UK EPR might be located is not known, but we consider, in the light of our assessment, that the highest total dose is estimated to be 31 μSv y^{-1}. It is very unlikely that doses at the site will exceed the site dose constraint of 500 μSv y^{-1}.

946 **We conclude that site dose should be assessed at site-specific permitting.**

13.7 Dose limit

947 There is also a dose limit (HMSO, 2010) for the maximum dose to any member of the public from ionising radiation. The dose limit is 1 mSv y^{-1} (1000 μSv y^{-1}) and it applies to the total dose from all artificial sources including past discharges, but excluding medical and accidental exposure.

948 **Comparison against the dose limit can only be done at site-specific permitting when contributions from all sources of radiation can be included.**

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[11] The constraint was set under the Basic Safety Standards Direction (Defra, 2000) but the Direction was superseded by the Environmental Permitting Regulations 2010.

13.8 Doses to people – collective dose

949 Collective dose is sometimes used as an indicator of the total radiation detriment to a population. It is the sum of all the doses received by the members of a population over a specified period of time. Collective doses are assessed in man-sieverts (manSv) (or sometimes as person Sievert). There are no limits or constraints for collective dose because collective doses are primarily for comparing the detriment from different options. However, the International Atomic Energy Agency (IAEA) has set a level for collective doses of less than 1 manSv per year of discharge as part of their criteria for discharges not requiring regulatory control.

950 The Health Protection Agency (GDA88) '*notes that the IAEA recommends that practices can be exempted from regulatory control only if both the criterion for collective doses and the criterion for individual dose (effective dose expected to a member of the public must be of the order of 10 µSv y^{-1} or less) are met*'. This requirement is stated in the International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources, IAEA Safety Series No. 115, 1996; in the IAEA Safety Guide on the Regulatory Control of Radioactive Discharges to the Environment, IAEA Safety Standards Series No. WS-G-2.3, 2000; and in IAEA Safety Guide on the Application of the Concepts of Exclusion, Exemption and Clearance, IAEA Safety Standards Series No. RS-G-1.7, 2004.

951 We agree with this point. We note that the assessment shows that collective doses are more than 1 personSv y^{-1} (for Europe and the World) and individual doses are greater than 10 µSv y^{-1}, indicating that the discharges should be regulated.

952 The UK Health Protection Agency, The Centre for Radiation Chemical and Environmental Hazards - CRCE), has provided additional guidance on assessing how important the collective doses are. It advises calculating an average dose to members of the population (per person doses). HPA-CRCE advised that if the average per person doses for a population group are only a few nano-sieverts (nSv, i.e. one thousandth of a microSievert) per year, we can consider them to be less important. If the per person doses increase above this level, we need to look more carefully at the discharge options.

953 EDF and AREVA provide information on collective dose (PCERsc11.1).

954 EDF and AREVA have estimated collective dose to UK, Europe and world populations truncated at 500 years using PC CREAM 98. Table 13.4 shows the results of EDF and AREVA's collective dose assessment.

Table 13.4 EDF and AREVA estimate of collective doses and per person dose from one year's discharges at maximum expected annual discharges

Population	Collective dose manSv (for one year of discharge)	Per person dose nSv (for one year of discharge)
UK	0.11	2.0
Europe	1.26	1.8
World	16.9	1.7

955 EDF and AREVA consider that the collective dose to all populations is dominated by releases of carbon-14 in both aqueous and gaseous radioactive waste.

956 We have also carried out our own calculations of collective dose. We did this for the UK, European and world populations over the next 500 years, assuming discharges are made at the maximum expected discharges of aqueous and gaseous radioactive waste. We used the PC CREAM 98 software to estimate collective dose. Our results are set out in the table 13.5 below.

Table 13.5 Our estimate of collective doses and per person doses from one year's discharges at maximum expected annual discharges

Population	Collective dose manSv (for one year of discharge)	Per person dose nSv (for one year of discharge)
UK	0.11	2.0
Europe	1.22	1.7
World	16.9	1.7

957 Comparing our assessment of collective dose and the assessment EDF and AREVA carried out shows almost identical results. Our assessment of collective dose similarly showed collective dose to be dominated by contributions from carbon-14 in discharges of both aqueous and gaseous radioactive waste.

958 For comparison, the annual collective dose to the UK population from background radiation has been calculated as 130,000 personSv (HPA, 2005). The collective dose from the UK EPR is above the IAEA level of 1 personSv per year of discharges, indicating that the discharges should be regulated. As the average per person doses are low, we consider that additional measures to minimise discharges are not required to control collective doses.

13.9 Doses to other species

959 We need to know the likely impact of the proposed discharges on non-human species to show that they will be adequately protected and that relevant conservation legislation will be complied with. In a similar way to the assessment of doses to humans, models of the behaviour and transfer of radionuclides within ecosystems are used to predict environmental concentrations, from which the radiation doses to reference organisms can be estimated. These doses can then be compared to 'guideline values' to assess the level of risk to flora and fauna. As described in our regulatory guidance note (Environment Agency, 2010d),we have adopted a value of 40 µGy h^{-1} as the level below which no further regulatory attention is warranted.

960 EDF and AREVA provide information on assessment of doses to non-human species in the PCERsc11.2. Their approach to assessing the impact on non-human species is as follows:

a) EDF and AREVA have predicted the maximum discharges of radionuclides in aqueous and gaseous radioactive waste that are likely to occur from their UK EPR design. They have used this data to assess the potential impact of the discharges to non-human species. (PCERc11)

b) In their assessment, EDF and AREVA used the ERICA (Environmental Risk from Ionising Contaminants: Assessment and Management) integrated approach (Beresford, 2007), which is the accepted practice within the European Union. The ERICA integrated approach aims to ensure that decisions on environmental issues give appropriate weight to the environmental exposure, effects and risks from ionising radiation, with emphasis on ensuring the structure and function of ecosystems.

c) To carry out the assessment, EDF and AREVA used the ERICA tool, which is a software programme that calculates the radiation dose rate that a reference organism is likely to receive from a defined activity concentration of a radionuclide. Reference organisms are used because, given the variation between species, it is not generally possible to develop species-specific assessment systems (as has been done for human radiation protection). EDF and AREVA have assumed that all reference organisms specified in ERICA are present and have included reference organisms that they consider to be typical or representative of terrestrial, freshwater and marine ecosystems.

961 The ERICA integrated approach has a default screening criterion for all ecosystems or organisms which is an incremental dose rate of 10 µGy h^{-1} below which 95 per cent of all species should be protected from ionising radiation (Andersson, 2009).

962 The ERICA integrated approach takes a tiered approach that allows progressively more detailed assessment depending on the magnitude of the dose rates calculated:

a) Tier 1 is simple and conservative – it requires a minimal amount of input data, the user can select from a range of radionuclides and calculate the dose rate for the most sensitive combination of reference organisms.

b) Tier 2 is more specific and less conservative – the user defines the radionuclides of interest and edits transfer parameters. Dose rates are calculated for each reference organism individually.

c) Tier 3 is very specific and detailed – used in complex and unique situations and involving a probabilistic risk assessment approach. A tier 3 assessment requires consideration of biological effects data.

963 EDF and AREVA used the following parameters in their assessment:

a) The maximum predicted activity concentrations of the radionuclides discharged to air and water that were used to derive activity concentrations in sea water, sea bed sediments, air and soil using the PC CREAM 98 model.

b) Default ERICA values for transfer parameters where available, and where not, values from IAEA TRS 422 (IAEA, 2004) or the most conservative parameter for that organism.

964 Results of the assessment carried out by EDF and AREVA:

a) EDF and AREVA carried out their assessment at tier 2 and considered the risk to terrestrial reference organisms from the predicted gaseous discharges and to marine reference organisms from the predicted aqueous discharges.

b) The results of their assessment identified that for each reference organism the probability of the predicted discharges exceeding the screening dose rate of 10 µGy h^{-1} is less than 1 per cent. The highest predicted dose rate for a terrestrial organism was calculated to be 0.003 µGy h^{-1} for a mammal and for a marine organism to be 0.01 µGy h^{-1} for a polychaete worm. (PCERsc11.2s2)

c) The greatest radiological impact to all non-human species from atmospheric discharges is from carbon-14. The radiological impact from marine discharges is generally greatest from carbon-14 and cobalt-60 depending on the species.

965 We carried out two evaluations of the assessment carried out by EDF and AREVA:

a) A validation exercise using the ERICA tool to satisfy ourselves that the results of the EDF and AREVA assessment were reproducible.

b) An independent assessment using the ERICA tool and the R&D128 approach ('Impact Assessment of Ionising Radiation on Wildlife', R and D Publication 128, Environment Agency, June 2003) to determine the dose rates using discharge data EDF and AREVA provided and predicted activity concentrations modelled for us by an independent contractor.

966 We were able to reproduce the results of the EDF and AREVA assessment when we used their input parameters. However, we did note that EDF and AREVA had not assessed the impact of noble gases on non-human species, but they state this will be carried out at site-specific permitting using the R&D128 approach. We carried out an assessment for noble gases using the R&D128 approach. For this, we used the EDF and AREVA maximum predicted activity concentrations and conservatively assumed that the reference organism was at the point of release. The maximum predicted dose rate was calculated to be 0.2 µGy h^{-1} for fungi, which does not exceed the screening dose rate of 10 µGy h^{-1}.

967 Our independent assessment identified that for each reference organism the probability of the predicted discharges exceeding the screening dose rate of 10 µGy h^{-1} is less than one per cent. The highest predicted dose rate for a terrestrial organism was calculated to be 0.1 µGy h^{-1} for a bird egg and for a marine organism to be 0.02 µGy h^{-1} for a mammal and reptile. To assess the risks from noble gases, we carried out an assessment following the R&D 128 approach using the predicted activity concentrations, which had been independently modelled for us by an independent contractor. The maximum predicted dose rate was calculated to be 0.00009 µGy h^{-1} for fungi.

968 A summary of the outcomes of a comparison of the EDF and AREVA assessment with our assessments is set out below:

<table>
<tr><th>Assessment type</th><th>Data source</th><th>EDF and AREVA results</th><th>Our results</th></tr>
<tr><td colspan="4">Terrestrial</td></tr>
<tr><td rowspan="2">ERICA
Tier 2</td><td>EDF and AREVA</td><td>No risk* for any individual reference organism. Maximum predicted dose rate is 0.003 µGy h^{-1} for a mammal</td><td>No risk* for any individual reference organism. Maximum predicted dose rate is 0.003 µGy h^{-1} for a mammal</td></tr>
<tr><td>Independent</td><td>-</td><td>No risk* for any individual reference organism. Maximum predicted dose rate is 0.1 µGy h^{-1} for a bird egg</td></tr>
<tr><td rowspan="2">R&D 128</td><td>EDF and AREVA</td><td>Not assessed</td><td>Maximum predicted dose rate is 0.2 µGy h^{-1} for fungi</td></tr>
<tr><td>Independent</td><td>-</td><td>Maximum predicted dose rate is 0.00009 µGy h^{-1} for fungi</td></tr>
<tr><td colspan="4">Marine</td></tr>
<tr><td rowspan="2">ERICA
Tier 2</td><td>EDF and AREVA</td><td>No risk* for any individual reference organism. Maximum predicted dose rate is 0.01 µGy h^{-1} for a polychaete worm</td><td>No risk* for any individual reference organism. Maximum predicted dose rate is 0.01 µGy h^{-1} for a polychaete worm</td></tr>
<tr><td>Independent</td><td>-</td><td>No risk* for any individual reference organism. Maximum predicted dose rate is 0.02 µGy h^{-1} for a mammal and reptile</td></tr>
</table>

* No risk means the probability of the predicted discharges exceeding the screening dose rate of 10 µGy h^{-1} is less than one per cent.

969 There is some variation between the results obtained using the predicted activity concentrations EDF and AREVA provided and those used in our independent assessment. This results in differences in the maximum predicted dose rates that we calculated compared to those calculated by EDF and AREVA. However, all the results are two or more orders of magnitude lower than the generic screening value and we do not consider that further assessment is justified at the GDA stage.

970 We obtained significantly different results using the R&D128 approach using the EDF and AREVA activity concentrations and those in our assessment. This is because our assessment using the EDF and AREVA activity concentrations had to conservatively assume the organism was living at the point of release. Our assessment using the activity concentrations was more realistic as it used dose rates calculated for an organism living 100 m from the point of releases. However, as the results from the conservative scenario do not exceed the screening dose rate, we do not believe further assessment is justified at the GDA stage.

971 We conclude that the assessment EDF and AREVA carried out is conservative and reasonable at the GDA stage, and we conclude that EDF and AREVA have used an

appropriate approach to assessing the radiological impact of the UK EPR on non-human species.

972 We note, however, that the EDF and AREVA assessment did not consider the impact that discharges of radionuclides might have on freshwater organisms or the impact of discharges of noble gases. Future operators will need to assess the impact of discharges of noble gases and freshwater organisms, or justify why this is not necessary. We require this information to be included as part of all site-specific radiological impact assessments for non-human species.

973 **We conclude that at the GDA stage we consider that the maximum predicted gaseous releases and aqueous discharges for a UK EPR at the generic site are unlikely to pose a risk to non-human species. We consider that the assessment is suitably conservative at this stage of the GDA process. A detailed site-specific assessment of the radiological impact from the UK EPR will be required for any site where the UK EPR is proposed.**

974 The Committee on Medical Aspects of Radiation in the Environment (GDA129) commented: '*The evidence base and the assessment methodology is more advanced for humans than it is for non-humans (or wildlife). Therefore, whilst the conclusions of low predicted doses for non humans appear reasonable, the confidence in the assessments is probably lower. For instance, the maximum predicted dose rates are, in some cases, for reference organism groups for which few, if any, transfer or effects data exist at present. Also, there is some potential confusion for the reader from the use of both the Erica screening value of 10µSv/h and the EA value of 40µSv/h. The use of a consistent methodology and criteria for the assessments for both designs is desirable for the future, and confidence in the assessment methodology and its underpinning science should be considered during detailed site-specific assessments.*' We provide some additional explanation of our methodology below:

Dose rate comparison

975 As part of non-human assessments we compare predicted dose rates to a screening value of 10 µGy h^{-1} (different to µSv h^{-1} used for human dose rate) which is protective of 95% of non-human species. This value is used to screen out sites of low regulatory concern, therefore if the dose rates to wildlife are calculated to be less than 10 µGy h^{-1} we do not require further assessments to be made. It was proposed by an European consortium of experts called PROTECT (Anderson et al., 2009). The value was derived using internationally agreed approaches for setting environmental thresholds (for example, species sensitivity distributions), therefore it was derived using the same methods as the criteria used in chemicals risk assessments (Copplestone et al., 2009).

976 We use an action level of 40 µGy h^{-1} when we determine permits. It is the level below which we consider that there will be no adverse effect on the integrity of a conservation site and was agreed with Natural England (Environment Agency, 2009). This value was derived from:

a) a comprehensive review of the available radiation effects data (Real et al., 2004) which found that in general, the dose rate threshold for significant adverse effects in non-human species was about 100 µGy h^{-1}; and

b) a review paper (Brown et al., 2004) which indicated that wildlife might receive up to 60 µGy h^{-1} from natural sources in European ecosystems.

977 Both values have been used in the generic design assessments in the way they are intended. In the first instance we compared the predicted dose rates to the 10 μG y^{-1} screening value to see if the sites could be screened out from further assessment. This gives us a high level of confidence due to the conservative nature of the screening value. If they could not, we compared the predicted dose rates to the 40 μGy h^{-1} action level to see if they were below the level which is considered to have no adverse effects on the integrity of a conservation site.

978 The predicted dose rates for the UK EPR generic design did not exceed the screening level of 10 μGy h^{-1}, therefore were screened out and not considered for more detailed assessment against the 40 μGy h^{-1}action level.

979 We will conduct more refined assessments for the site-specific applications.

Confidence in the assessment methodology

980 The assessment methodology for non-humans is less advanced for humans and therefore it is inevitable that confidence in dose assessments is lower. There are no species-specific models for wildlife, nor detailed assessments of doses to different organs like there are for humans.

981 The ERICA Tool was recommended for completing chronic exposure assessments for non-human species by the PROTECT consortium (Howard et al., 2010). The tool has been maintained and improved since this recommendation was made, and we have continued to be involved in this process. Therefore we are happy that it was adequate to use for the prospective assessment for the generic designs and remains fit for our purposes.

982 We are participating in model inter-comparison exercises as part of a working group of the International Atomic Energy Agency (IAEA). ERICA performs reasonably well against other available tools, and where it has been possible to test model predictions (e.g. Beresford et al., 2009). ERICA has also performed reasonably well predicting dose rates to biota (e.g. Beresford et al., 2010).

983 In the event of gaps in the data needed to complete assessments, conservative assumptions were made (both in the ERICA Tool development and in our generic design assessments) to ensure the final result was likely to be an over-prediction of dose. This gives confidence at this generic assessment level in the overall results.

Transfer factors

984 Where possible most of the default transfer factor values in the ERICA database were derived from a review of original publications. However, for many of the organism-radionuclide combinations there were no reported data from which to derive values. These data gaps were dealt with in a conservative manner, for example, by using values for organisms of similar taxonomy, or the highest available value for elements of similar biogeochemistry.

985 We are working to improve this by actively participating in the working group responsible for the IAEA’s handbook of parameter values for the prediction of radionuclide transfer to wildlife, which is due to be published in 2011. This provides an up-to-date review of all available transfer parameters. We will take the parameter values into account when completing the site-specific assessments.

Effects data

986 The effects dataset available for reference organism groups is by no means complete. It would be very expensive and time consuming to conduct experiments to assess the effects of chronic radiation exposure to each reference organism.

987 A database of data on radiation effects for all species has been developed, called FREDERICA. This is the most comprehensive source of radiation effects data available, and was used to derive the 10 µGy h^{-1}screening value within the PROTECT project. By comparing the predicted dose rates to this screening value, we are considering the best available dataset on radiation effects data for all species, including sensitive species. Note that the limiting reference organisms are those that are predicted to receive the highest dose rate from the radioactivity discharged, not necessarily the most sensitive organisms to radiation.

988 Furthermore, the ICRP Committee 5 on Environmental Protection has defined Derived Consideration Reference Levels (ICRP, 2008); these are consistent with our dose rate predictions for different wildlife species. While the ICRP is continuing its work in this area, our generic design assessments have been conducted in line with the current knowledge and application of a radiological protection of the environment approach.

989 Protected species may be identified to be present near the locations for the site-specific assessments. At the moment, our generic design assessment has assessed the likely dose rates to them using the reference organisms given in the ERICA Tool. We will however conduct more refined assessments as appropriate for the sites identified for potential new build. In these more refined assessments, specific efforts will be made to predict dose rates to protected species for comparison to the screening value and, if necessary, to the action level.

14 Other environmental regulations

14.1 Water Resources Act 1991 (as amended): Water abstraction

14.1.1 Conclusions

990 Our conclusions have been updated since our consultation to reflect the concerns of respondents about damage to marine life at seawater intakes.

991 **We conclude that:**

a) **The EDF and AREVA GDA proposal to abstract cooling water only from the open sea is unlikely to require an abstraction licence from us.**

b) **The design of the seawater intake to minimise damage to marine life will be a site-specific issue**.

992 Our conclusions refer to the EDF and AREVA GDA generic site that is a coastal location where direct cooling of the steam turbine condensers by seawater will be used. Future operators will need to demonstrate for each location that BAT will be used for cooling, abstraction will only be relevant if direct seawater cooling is demonstrated as BAT.

14.1.2 Background

993 EDF and AREVA say that the UK EPR will need supplies of freshwater for several purposes (PCERsc3.4s1.1):

a) to supply the demineralisation plant that provides treated water for the primary and secondary circuits;

b) for the industrial water system in the turbine hall;

c) potable water for sanitation needs (showers and lavatories), for the laundry and for firewater and other purposes.

994 The annual requirement for freshwater for a UK EPR is likely to be 331,600 m^3. Providing freshwater will be a site-specific issue, and we have not considered this at GDA. EDF and AREVA mention using a desalination unit or abstraction from surface water sources such as a river or groundwater depending upon site characteristics. If the site needs abstracted surface water or groundwater, then the operator will need to obtain an abstraction licence from us before any abstraction takes place.

995 One respondent (GDA40) raised concerns on the conflict of fresh water supply to people or to industry. This will be a site-specific issue and we may not have direct involvement if a future operator negotiates directly with a supplier.

996 EDF and AREVA only consider direct cooling of the steam turbine condensers by seawater in GDA. We accept that direct cooling may be the best option for estuarine and coastal sites, provided that the highest standards of planning, design

and mitigation are followed (see Environment Agency, 2010b). The National Policy Statement for Nuclear Power Generation (DECC, 2011a) states at section 3.7.7: '*Applicants will be expected to demonstrate Best Available Techniques to minimise the impacts of cooling water discharges*'.

997 EDF and AREVA estimate that, allowing for a temperature increase of 12°C at the discharge point, the flow rate of seawater for cooling will be 67 $m^3 s^{-1}$. The total annual volume of seawater required will, therefore, be around 2.1 billion m^3.

998 If a desalination unit were used to supply freshwater, see above, an additional annual volume of 680,000 m^3 seawater would be needed.

999 The abstraction of water from the open sea will not normally require an abstraction licence from us, unless the particular location of the abstraction means that it falls within the definition of inland waters under the Water Resources Act 1991. We have assumed for GDA that the cooling water intake will be from the open sea and that the abstraction will not require licensing. We will need to examine carefully the location of abstraction for each specific site to decide whether a licence is needed. Future operators will need to contact us for advice, giving full details of their proposals.

1000 The abstracted seawater will need to be filtered to remove debris, including seaweed before it is used. EDF and AREVA describe using pre-filters followed by drum and chain filters (PCERsc3.4s3.2.1). Handling the removed material will need to be considered for each site, it will be a waste for disposal. In some cases, it can be macerated and returned to the sea. The future operator for each specific site will need to discuss with us the need for waste or water discharge permits for the option chosen for the site. We have not assessed this matter at GDA.

1001 We have concerns on the seawater intake design because of possible damage to fish and invertebrates through entrapment and impingement on filter screens. We published a report in 2010 '*Cooling Water Options for the New Generation of Nuclear Power Stations in the UK'* (Environment Agency, 2010b) that explains the issues and reviews mitigation measures. We expect operators to contact us at the early stages of site-specific designs so that we can advise on techniques to minimise the impact of cooling water intakes on the marine ecology. We will assess and comment on the proposed intake design in our role as statutory consultee in the planning process. If the abstraction were licensable (under the Water Resources Act 1991), then we would also seek to influence the design through agreed conditions on the abstraction licence, for example, requiring the operator to install mitigation measures and / or carry out monitoring programmes.

1002 There were seventeen responses about this topic and most agreed with our conclusion that abstraction from the open sea would not require an abstraction licence.

1003 However, most respondents, in particular, Seafish (GDA90), Stop Hinkley (GDA159) and West Somerset Council and Sedgemoor District Council (GDA154) were very concerned about the impact on marine life due to entrapment in the cooling water and impingement on filter screens. As noted above we have no immediate regulatory control on abstractions from the open sea. We seek to influence operators at the early stage of projects (our report '*Cooling Water Options'* mentioned above) and through the planning process.

1004 The Countryside Council for Wales (GDA143) has a number of concerns about the choice of a coastal location as the generic site and that direct cooling by seawater is taken as BAT. Also that the environmental impact of the intake and use of biocides are significant. CCW was disappointed that GDA did not provide more detail on these issues. We mention above that we only consider the generic site defined by EDF and AREVA, that is a coastal location. There are a number of options that future operators can use to provide cooling depending upon location and we believe that any issues can be resolved at the site-specific stage.

1005 On a similar note one respondent (GDA112) was concerned we did not consider estuarial locations at GDA. As noted above the generic site did not include estuaries, we agree with the respondent that considerable assessment work would be needed to confirm suitability of a design for estuaries and that alternative cooling strategies involving cooling towers may be needed.

1006 Two respondents, both future operators, NNB Genco (GDA106) and Horizon Nuclear Power (GDA127), undertook to ensure that intake design on their sites would be designed to minimise impact on the local marine environment.

14.2 Environmental Permitting Regulations 2010 (EPR10): Discharges to surface water

14.2.1 Conclusion

1007 Our conclusion has been updated since consultation. Some respondents were concerned about the impact of biocides. We undertook additional assessment that is summarised in section 14.2.2 and include the outcome within conclusion a) below.

1008 **We conclude that:**

a) **the predicted discharges of non-radioactive substances from a UK EPR are less than one per cent of any environmental quality standard at the point of disposal to the sea with the exception of biocide used to control fouling, however additional breakdown in the mixing zone around the outlet would be expected to meet the relevant standard, and therefore should be compatible with the Water Framework Directive aim of achieving good ecological and chemical status in the receiving water; and**

b) **we should be able to permit the discharges of non-radioactive substances to water from a UK EPR under EPR 10. However, this will depend on our determination of site-specific applications and any application for a permit will need to provide a detailed environmental impact assessment based on dispersion modelling**.

14.2.2 Background

1009 We have assessed (within the constraints imposed by the generic site) whether discharges to water from the UK EPR could pose an unacceptable risk to the environment.

1010 The underlying objective of our detailed assessment is to determine whether we could grant a water discharge permit for the UK EPR design, subject to any matters that can only be dealt with at the site-specific stage.

1011 We received fourteen responses related to this topic. The responses were generally supportive of our conclusions but some raised additional concerns:

a) Choice of biocides used needs careful consideration (GDA38). This will be a future operator decision, we expect justification of biocides proposed to be provided with site-specific applications.

b) GDA38 – there are alternatives to hydrazine so this discharge could be eliminated [a respondent under the COMAH topic also raised this issue]. Again we expect a site operator to justify his choice of oxygen scavenger and other chemicals used as corrosion inhibitors such as morpholine and trisodium phosphate.

c) GDA40 – the heat impact is concerning particularly if discharge is alongside existing plant or if a site has more than one reactor. We recognise this but we note below that we cannot consider this at GDA, it can only be assessed properly at the site-specific stage when the full heat load is known and the receiving environment defined. There are measures that can be employed if required, such as 'helper' cooling towers (these are only used for partial cooling of discharges when receiving water temperatures are high in the summer). We will not permit a discharge that will cause damage to the environment.

d) In particular Seafish (GDA90) noted '*fish kills associated with… thermal pollution…may well assume greater significance in an era when aquatic ecosystems are under stress, and hence vulnerable, through the impacts of climate change*'. Assessing the thermal plume in the context of climate change will be an important consideration for site-specific applications. Our current guidance on thermal plume modelling requests applicants to cover a range of plausible scenarios of climate-change driven rises in air and sea temperatures and sea-levels over the planned life-time of the station. We are discussing the scope and details of this work with future operators.

e) GDA51 – effluent from conventional drains or sanitation systems is not covered. We say below that such systems will need to be considered at the site-specific stage. Some sites may be able to use the public sewerage system, otherwise such effluent will be the same as other large industrial sites and it can be treated by standard techniques.

f) The Health Protection Agency (GDA88) says that we should expand the range of contaminants assessed for impact on health. We have advised potential operators that that they will need to provide more detailed information in applications for site discharge permits, in particular for trace metals.

g) There was a query at our stakeholder event about boron discharges. There will be boron discharged from the UK EPR but the impact is shown below as 0.008 % of the environmental quality standard.

1012 The key issues for assessing non-radioactive discharges to water are the discharge of certain dangerous substances and the discharge of thermally adjusted cooling waters. Both these matters would be subject to control by an environmental permit from us (Environmental Permitting Regulations 2010, EPR 10).

1013 Dangerous substances (as specified under the Dangerous Substances Directive) and priority substances and priority hazardous substances (as specified under the Priority Substances Directive) are toxic and pose the greatest threat to the environment and human health. The Directives require that we either eliminate or minimise pollution by these substances. We define pollution by dangerous substances / priority substances as exceeding environmental quality standards (EQSs) in the water. The EQS defines a concentration in the water below which we are confident that the substance will not have a polluting effect or cause harm to plants and animals.

1014 The requirements of the Dangerous Substances Directive are now integrated in the Water Framework Directive, and the Dangerous Substances Directive will be fully repealed in 2013. The Priority Substances Directive now applies to discharges of priority substances and sets EQSs for priority and priority hazardous substances. The Water Framework Directive is designed to improve and integrate the way water bodies are managed throughout Europe. Member states must aim to reach good chemical and ecological status in inland and coastal waters by 2015. This overarching piece of legislation will have wide implications for any new nuclear power station built in Europe, not least because EQS compliance serves as a key indicator of both chemical and ecological status.

1015 Heat is defined as pollution under the Water Framework Directive. Under the Directive, draft temperature standards have been published based on the requirements for coastal and transitional waters of good ecological status. In common with other directly cooled power stations (both conventional and nuclear), the UK EPR will produce and discharge large volumes of thermally adjusted cooling waters. The main environmental effects of these thermal discharges relate to temperature rise and cooling water system biocide residues.

1016 Other important legislation to be considered is the Habitats Directive. The Directive creates a network of protected areas around the EU called European sites which form the 'Natura 2000' sites network. These sites are found in abundance at various locations around the UK's coastline and could potentially be affected by new nuclear power station discharges.

1017 At GDA it is not possible to assess the UK EPR discharge under the Habitats Directive. To determine whether a discharge is 'relevant' under the legislation, we would need to pinpoint it to a particular location. If the discharge were 'relevant', we would apply increasingly rigorous assessment stages, ultimately requiring site-specific knowledge about how a discharge plume would behave in the receiving water. Detailed dispersion modelling could be required and this is outside the scope of GDA.

1018 EDF and AREVA have carried out an ecological impact assessment based on a representative UK site (PCERsc12.3s3.2). While this is useful as it demonstrates an awareness of the relevant issues, identifying potential impacts and mitigation measures, the results are inconclusive due to the generic nature of the assessment. EDF and AREVA have identified the considerable limitations for this work under GDA and point towards the need for site-specific work to properly assess ecological impacts. This is consistent with our understanding and is consequently why we have not assessed this issue at GDA.

1019 EDF and AREVA say that the UK EPR will generate aqueous effluents of two types (PCERsc3.4s5.1):

a) aqueous radioactive effluent associated with the reactor coolant. The radioactivity of this effluent is dealt with in chapter 9, but the effluent will also contain chemicals and metals, for example, corrosion products, that will need to be covered in a discharge permit from us;

b) non-radioactive effluent coming from conventional parts of the UK EPR such as the demineralisation plant, seawater chlorination facility, turbine hall and the site sewage treatment facilities.

1020 The main chemicals used in the UK EPR and associated with the aqueous radioactive effluent are (PCERsc3.4s5.3.1):

a) boric acid added to the coolant as a neutron absorber;

b) lithium hydroxide added to the coolant to offset the acidity of the boric acid to prevent equipment corrosion;

c) hydrazine used as an oxygen scavenger in the feedwater;

d) ammonia, morpholine and ethanolamine to adjust pH of secondary circuit water to minimise corrosion;

e) trisodium phosphate used in some auxiliary cooling and heating circuits as a corrosion inhibitor;

f) detergents used in the laundry to clean work clothes.

1021 Metals will arise from corrosion and erosion where coolant and other process waters contacts equipment. Metals used in the UK EPR equipment include aluminium (Al), copper (Cu), chromium (Cr), iron (Fe), manganese (Mn), nickel (Ni), zinc (Zn) and lead (Pb). The UK EPR uses chemical controls to minimise corrosion. Effluents are filtered and, where possible, passed through ion exchange resins. These techniques will minimise the quantities of metals present in discharges.

1022 Suspended solids may come from dust in drain effluents or from raw water used in some auxiliary circuits.

1023 Chemical oxygen demand (COD) will arise from detergents and other organic chemicals used such as morpholine and ethanolamine.

1024 EDF and AREVA predict the annual discharges of chemicals associated with radioactive effluent to be (PCERsc3.4 Table 3):

Chemical	Expected discharge without contingency (kg)	Maximum annual discharge (kg)
Boric acid (as boron)	2,000 (350)	7,000 (1,224)
Lithium hydroxide	less than 1	4.4
Hydrazine	7	14
Morpholine	345	840
Ethanolamine	250	460
Nitrogen compounds (as N) excluding hydrazine, morpholine and ethanolamine	2,350	5,060
Phosphate	155	400
Detergents	630	1,600
Metals	16	27.5
Suspended solids	655	1,400
Chemical oxygen demand	1,490	2,525

1025 EDF and AREVA have not carried out an impact assessment for those substances used as circuit conditioners (both primary and secondary circuits) that do not have an EQS. These substances require further assessment and may potentially be subject to control in a water discharge permit. The operator will need to expand on this topic and provide additional information on the impact of these substances in support of a site-specific application for a water discharge permit. Circuit conditioning products should, however, breakdown readily upon dilution with the cooling water return and upon mixing within the marine environment.

1026 The distribution of metals is predicted in PCERsc3.4 Table 5:

Al	Cu	Cr	Fe	Mn	Ni	Pb	Zn
8.95%	0.7%	14.1%	59.3%	5.6%	0.75%	0.5%	10.1%

1027 In addition to the metals listed above, EDF and AREVA state that traces of mercury, cadmium and arsenic can be present in raw conditioning materials. They also state that silver can arise in trace amounts from corrosion of control rods, although it is not likely to be found as in impurity within bulk raw materials.

1028 EDF and AREVA have not provided estimates of discharges of these substances at GDA. However, it is likely that their presence in the discharge will be at low concentrations, possibly trace amounts following filtering and ion exchange treatment. More detailed information will be required for a site-specific application for a water discharge permit.

1029 We have published a study to help us understand the range and quantity of chemicals discharges: '*Chemical Discharges from Nuclear Power Stations: Historic Releases and Implications for BAT'* (Environment Agency, 2011a). The report will also support our site-specific permitting work.

1030 UK EPR aqueous effluents will be collected in tanks – the LRMDS, ExLWDS or CILWDS tanks as already described above. After sampling and analysis, the contents of the tanks may be authorised for discharge under an internal management procedure. The discharge will be through discharge points W1 and W2 to join the cooling water at the discharge pond. We anticipate that the flow metering and sampling equipment at W1 and W2 specified for radioactivity discharge monitoring will also be used for chemicals and metals monitoring.

1031 EDF and AREVA say that demineralised water needed for use in the UK EPR will be produced by a demineralising plant using a fresh water supply or a desalination plant. Both plants would produce effluent and, as an example for GDA, they predict the following annual discharges based on 40 days use of demineralisation and the rest of time by desalination (PCERsc3.4s5.4.1.1):

Substance	**Annual discharge (kg)**
Suspended solids	1,621
Iron	848
Chlorides	3,616
Sulphates	11,725
Sodium	13,523
Detergents	312

Table from PCERsc3.4s5.4.3.1 (Table 6)

1032 EDF and AREVA have not provided information on trace metal contamination of raw materials such as sodium hydroxide and sulphuric acid used in a demineralisation plant. Contamination usually includes cadmium and mercury, which are dangerous substances. However, it is likely that their presence in the discharge will be at low concentrations, possibly trace amounts. More detailed information will be required for a site-specific application for a water discharge permit.

1033 Seawater cooling circuits need to be protected from biological fouling when the seawater inlet temperature is above 10°C. The UK EPR will use an electrolysis system to produce sodium hypochlorite within the seawater. The system will leave residual oxidants and bromoform in the returning seawater. (PCERsc3.4s5.4.1.3)

1034 The electrochlorination process is site-specific and depends on local water quality. However, EDF and AREVA have provided some predictions of discharge concentrations for residual oxidants and bromoform under different treatment scenarios. Increased dosing levels will be necessary where changes in water quality cause excessive biofouling, or where it is necessary to treat those parts of the circuits that are particularly prone to biofouling.

1035 EDF and AREVA have provided an estimate of the impact from the electro-chlorination process, quantifying the likely concentrations of TRO (Total Residual Oxidant) against its respective EQS – see the table below (PCERsc12.2 Table 5). While they conclude that the area of water exposed to TRO concentrations which exceed the EQS is likely to be limited to the immediate vicinity of the discharge point, they confirm that this is a highly site-specific assessment area. This is consistent with our understanding and is consequently why we have not assessed this issue at GDA. Future work involving using local water quality information and dispersion modelling would be necessary to support a site-specific application for a water discharge permit.

1036 The site of a UK EPR will need a sewerage system to collect (and treat where necessary) rainwater, wastewater from lavatories, water drainage that might contain oil and demineralisation plant effluents. The system will be site-specific and, therefore, has not been assessed under GDA. We note that EDF and AREVA have identified that oil traps and a retention area (to collect fire water or accidentally polluted water) will be needed in such a system and we confirm that we will require these techniques. The operator will need to provide details and justification of the site-specific design in an application for a water discharge permit. (PCERsc3.4s5.4.1.4/5)

1037 The discharge arrangements for the demineralisation plant and sewage system are not defined at GDA. The operator for a specific site will need to define all points of discharge, detail flows and composition of effluent at each point and provide appropriate MCERTS flow metering and sampling equipment.

1038 EDF and AREVA have provided an impact assessment for some of the substances discharged to sea from a UK EPR. This follows the principles of the Environment Agency's H1 guidance (modified slightly to better reflect the discharge of substantial plumes to the marine environment) (Environment Agency, 2010e). H1 is used for assessing the risks to the environment and human health from facilities that are applying for a permit under the Environmental Permitting Regulations 2010. Insignificant risks are screened out and more detailed assessment is only needed where the risks justify it.

1039 EDF and AREVA have assessed those substances that currently have an EQS. They include:

a) metals contained in the radioactive aqueous effluent and non-radioactive demineralisation plant effluent;

b) other circuit conditioning chemicals (PCERsc12.2s2.5).

1040 The assessment of metals takes into account the corrosion (and erosion) products arising in both the primary and secondary circuits and which are collected in the LRMDS and CILWDS tanks. From PCERsc12.2 Table 5:

1041

Substance	Annual discharge (kg)	Discharge concentration ($\mu g\ l^{-1}$)(DC)	Environmental quality standard ($\mu g\ l^{-1}$)(EQS)	DC/EQS (%)
Ammonia unionised (as N)	167	0.08	21 (our proposed EAL)	0.4
Boron	1224	0.58	7,000	0.008
Iron	864	0.41	1,000	0.04
Copper	0.19	0.0001	5	0.002
Nickel	0.21	0.0001	30	0.0003
Chromium	3.88	0.002	15	0.0122
Zinc	2.78	0.0013	40	0.0033
Lead	0.14	0.00007	25	0.0003
TRO (Total Residual Oxidant)	-	500	10	5000

Notes: EDF and AREVA conclude that the area of water exposed to TRO concentrations which exceed the EQS is likely to be limited to the immediate vicinity of the discharge point. As the fate of chlorine in seawater is a highly complex issue further site-specific studies will be required in this area.

1042 The discharge concentration (DC) is that at the final discharge point to the sea after the effluent has been diluted with 67 $m^3 s^{-1}$ of returning cooling seawater. The discharge concentrations of all metals assessed are well below one per cent of their EQS.

1043 Our procedures for permitting dangerous and priority substances to coastal waters are based on the relationship between the discharge concentration and the EQS. We again apply a staged approach, which involves more rigorous assessment as each stage is passed. The rigour of each stage is reflected in the need for increasing levels of site-specific information and possibly dispersion modelling studies.

1044 If the discharge concentration of a substance is much less than the EQS then it is considered insignificant. At the other end of the scale, we may have to define what is an acceptable '*mixing zone'* for a particular substance, taking account of local constraints such as sensitive ecological areas and specify appropriate limits for that substance on a discharge permit.

1045 The discharge concentrations for dangerous and priority substances estimated by EDF and AREVA suggest that in terms of our assessment, these concentrations are not significant. More detailed information would be required in support of a site-specific permit application, in particular information on those metals not considered so far, for example, aluminium and manganese and more harmful substances, such as cadmium and mercury.

1046 EDF and AREVA say that the thermal impact of the returning cooling seawater (67 m^3s^{-1} at 12°C above the inlet water temperature) can only be modelled on a site- specific basis. This is consistent with our understanding and, therefore, we have not assessed potential thermal impact under GDA. Due to the highly localised data requirements of dispersion modelling, a detailed study will be required for a site-specific application for a water discharge permit.

1047 We have identified above a number of issues to be resolved at the site-specific permitting stage. This is because in order to fully assess the environmental impact of the UK EPR discharge we require an accurate representation of the behaviour of the receiving waters and of their interaction with the various substances to be discharged. This can only be achieved by computational dispersion modelling, using localised monitoring data – this is outside the scope of GDA. Nevertheless, based on our assessment of the information submitted by EDF and AREVA, we believe, in principle and without prejudice to our formal determination of an application in due course, that we should be able to grant a permit to discharge liquid effluents from the UK EPR to the sea.

1048 A future operator, Horizon (GDA127), welcomed our comments but said that '*many of the factors surrounding the discharge of non-radioactive substances will be site-specific and will be addressed as part of the Environmental Impact Assessment (EIA) and Environmental Permit (EP) application submissions*.'

1049 West Somerset Council and Sedgemoor District Council (GDA155) provided some detailed comments. We agree with these important comments and copy below:

'Recognition of the contributing effects of heat and biocide in cooling water as pollution from cooling water discharges is welcome. Particularly so is also recognition in this context of the importance of the Habitats Regulations and the affect of cooling water discharge with regards to the Habitats Regulations. While we agree that Habitats Regulations Assessment is not directly underpinning to the GDA process, we welcome discussion of the importance of it at an early stage, and the Environment Agency expectation for increasingly rigorous assessment and the possible need for detailed dispersion modelling to support this.

We further agree with the Environment Agency decision not to assess the ecological impact assessment of a representative site conducted by EDF and AREVA. Inconclusive and limited findings may otherwise affect the confidence afforded to conclusive and evidence based site assessment required of the Habitats Regulations Assessments.

The authorities further recognise the importance of full and robust assessment of the impact of discharge of cooling water at elevated temperatures to marine and estuarine water bodies. We fully support the requirement (para 685) that 'due to the highly localised data requirements of dispersion modelling, a detailed study will be required for a site-specific application for a discharge permit' and also suggest that this also needs to ensure that thermal plume discharge modelling takes full account of all modes of operation (including redundancy of cooling water infrastructure) and also adjacent thermal outfalls where, for example, new reactors are constructed adjacent or within the possible mixing zone of established reactors.'

14.3 Environmental Permitting Regulations 2010 (EPR10): Discharges to groundwater

14.3.1 Conclusion

1050 Our conclusions remain unchanged since our consultation.

1051 **We conclude that:**

a) **the site of a UK EPR should not need to be permitted by us for a discharge to groundwater under the Environmental Permitting Regulations 2010;**

b) **pollution prevention techniques used in the UK EPR are adequate to prevent any leaks or spills entering groundwater**.

14.3.2 Background

1052 Under the Environmental Permitting Regulations 2010 (EPR 10), a permit is required for the discharge of certain substances, to groundwater, with the aim of preventing or limiting pollution of groundwater.

1053 EDF and AREVA claim that there is no likelihood of direct or indirect discharges of relevant substances to groundwater from the UK EPR. In that case, a UK EPR should not need to be permitted by us for a discharge to groundwater under EPR 10.

1054 Eight responses related to this topic and were generally supportive of our conclusions. A number highlighted the importance of using pollution prevention techniques from the beginning. Also that the use of a borehole network to monitor for all types of contamination is best practice. The Health Protection Agency (GDA88) in particular supported use of the borehole network to monitor for a range of non-radioactive substances.

1055 EDF and AREVA list the following substances relevant to groundwater pollution as liable to be on a UK EPR site (PCERsc12.2s2.2):

a) hazardous substances: hydrazine hydrate, bromoform, hydrocarbons and radioactive substances;

b) non-hazardous pollutants: metals, phosphates, ammonia and nitrates. '*Non-hazardous pollutant*' is a term used by the Groundwater Directives as another category to '*hazardous*', it should not be regarded as a comment on hazard as generally understood. '*Hazardous*' substances are especially toxic and persistent in groundwater terms.

1056 Diesel fuel (a hydrocarbon) used by the UK EPR stand-by generators will present a potential risk to groundwater. However, its use will be within a permit from us, see chapter 14.4 below, and we will ensure through that permit that BAT are used to prevent any discharge to groundwater.

1057 EDF and AREVA claim that any other '*storage tanks, chemical stores, refuelling areas and other activities that have the potential to pollute the environment will be placed on hard surfaces or bunded to contain spills*'. We will inspect facilities on specific sites during construction to confirm that appropriate prevention measures are in place before operations commence. (PCERsc12.2s2.2)

1058 EDF and AREVA identify that the operator of a UK EPR site will need to have emergency procedures to be implemented in the case of any accidental spillage. The procedures should ensure that sources of contamination are found quickly and that the sources and any contaminated soil are treated to protect groundwater from pollution. We confirm that we expect operators to have such procedures in place before operations commence. Ensuring adequate measures are available for handling firewater is also an important emergency provision.

14.4 Environmental Permitting Regulations 2010 (EPR10): Combustion plants

14.4.1 Conclusion

1059 Our conclusions remain unchanged since our consultation.

1060 **We conclude that:**

a) **the UK EPR's emergency diesel generators (EDG) will be a Part A(1) installation as described in section 1.1 of chapter 1 in Part 2 of Schedule 1 of EPR 10. The operation of the EDG will require an environmental permit from us;**

b) **we should be able to issue a permit under EPR 10 for the operation of the EDG, but any application for a permit will need:**

   i) **a BAT assessment for the chosen diesel engine;**

   ii) **site-specific modelling to demonstrate compliance with air quality objectives.**

14.4.2 Background

1061 The Environmental Permitting Regulations 2010 (before 1 April 2008 installations were regulated under PPC (Pollution Prevention and Control Regulations 2000)) require operators of installations containing certain activities to apply for and obtain a permit from us before commencing operations. In relation to the UK EPR, combustion activities, where fuel is burned in two or more appliances with an aggregated rated thermal input of 50 MW or more, are relevant.

1062 The UK EPR will include four main emergency backup electricity generators (emergency diesel generator – EDG). Each will have a thermal input of 17.6 MW to generate 7.5 MW of electricity. There will also be two ultimate emergency backup generators (station black out – SBO), each of 6 MW input to generate 2.5 MWe. The total thermal input for the six diesels (compression ignition engines) will be 82.4 MW, therefore any operator of a UK EPR will need to obtain a combustion activities permit from us. (PCERsc3.3s4.2.1.1)

1063 Seven respondents agreed with our conclusion that the EDGs will require an EPR 10 permit.

1064 One individual respondent (GDA38) was concerned that the diesel engines chosen will need to have the lowest emissions and noise levels. We will only permit the EDGs if the future operator can demonstrate that the chosen engines are BAT for emissions and noise level.

1065 The emergency generators are all nuclear safety equipment to provide backup power supplies in the unlikely event of loss of off-site supply or if UK EPR load operation fails. They will not normally operate except for periodic testing. EDF and AREVA claim that the estimated annual running time of each diesel should be less than 20 hours.

1066 EDF and AREVA say that the choice of diesel generator suppliers will only be made at later stages of construction. Therefore, precise details of diesel performance and discharges can only be provided at the site-specific permitting stage. They have provided *'Generic information for UK EPR diesel generators*' in the supporting document UKEPR-0004-001. We have reviewed the document and have the following comments:

a) Site Report – this is a site-specific issue and cannot be assessed at GDA.

b) A technical description is provided: essentially there are two buildings each with two EDGs and one SBO, each EDG having a fuel oil storage tank of 180 m^3 capacity and each SBO having a fuel oil storage tank of 25 m^3 capacity. The operator will need to demonstrate that BAT are used for the design of the buildings and facility to prevent any leaks of oil reaching land or groundwater.

c) The main aerial emissions of concern are sulphur dioxide (SO_2) and oxides of nitrogen (NOx) in the waste combustion gases:

   i) minimisation of emissions of SO_2 will be by using low sulphur content fuel oil (current UK regulations limit sulphur content to 0.1 per cent by weight), we accept this as BAT;

   ii) minimisation of emissions of NOx will rely on engine design and will not be confirmed until a late stage of site-specific permitting. EDF and AREVA have quoted a typical discharge concentration of 2,542 mg m^{-3} NOx (as nitrogen dioxide, NO_2 at 5 per cent oxygen). The operator will need to provide a detailed BAT options appraisal with the permit application to show that the engine chosen minimises discharges of NOx. We believe that the concentration quoted as typical is high and that engines are currently available with much lower discharge concentrations of NOx. This is a technology area where improvements are taking place and we expect the operator to review latest available equipment to identify BAT.

   iii) EDF and AREVA review abatement techniques for NOx (for example, selective catalytic reduction). It is likely that none will be BAT when the intermittent basis of operation (20 hrs y^{-1}) is considered. EDF and AREVA defer any decision on abatement until the site-specific stage, the operator will need to provide evidence that abatement options have been considered in the application BAT assessment.

d) The Health Protection Agency (GDA88) reminded us that all pollutants not just SO_2 and NOx need to be considered. We will undertake a full assessment before issuing a permit. Carbon monoxide, particulates and volatile organic compounds (VOCs, in this case unburnt hydrocarbons) are among the pollutants that will be assessed.

e) The operator will need to show that there will be appropriate management systems in place for the installation. This is an operator and site-specific issue and is not assessed at GDA. EDF and AREVA suggest an environmental management system such as ISO 14001:2004 would be appropriate and we agree with this suggestion.

f) Apart from fuel oil there will be few raw materials used – some lubricating oil and antifreeze – and little waste generated.

g) One respondent (GDA38) was concerned to ensure that adequate bunding of fuel tanks should be employed. Effective bunding to 110% of capacity of the largest tank is a requirement to be able to obtain an EPR 10 permit.

h) Cooling water for the engines will be in a sealed system, so there should be no liquid effluents to be disposed of to the sea.

i) The generators are essential for safety of the nuclear plant and, therefore, energy efficiency concerns are not appropriate. EDF and AREVA state that any electricity generated during tests would be exported to the grid together with the electricity generated by the UK EPR itself.

j) Noise from the operation of diesel generators can be an issue. EDF and AREVA say that as operation of the generators is intermittent so noise generated will also be intermittent. However, we believe intermittent noise can have its own issues and an operator will need to show procedures to minimise any impact. The operator will need to show that the design of the generator buildings and engine exhaust silencers are BAT to minimise impact of noise.

k) We are unlikely to require any continuous monitoring of emissions from the diesel engines or any environmental monitoring. Occasional testing of emissions by MCERTS portable equipment should be enough.

l) Diesel generators and their associated facilities should not be a significant issue at site closure.

m) EDF and AREVA expect the annual fuel usage to be 31 te for each EDG and 10.5 te for each SBO, a total of 145 te. On this fuel usage the annual emission of sulphur dioxide (at 0.1 per cent sulphur content) would be 290 kg. The annual NOx emissions are quoted as 1.7 te for each EDG and 0.6 te for each SBO, an annual total of 8 te (as NO_2). These emissions are not significant on a national basis, the national atmospheric emissions inventory 2006 gives SO_2 as 676,000 te and NO_2 as 1,595,000 te.

n) For local impact, SO_2 and NO_2 are subject to the Air Quality Regulations and the operator will need to demonstrate that emissions from the diesel installation will not compromise environmental quality standards. EDF and AREVA used our H1 methodology (Environment Agency, 2010e) to generate some impact values, PCERsc12.1s2.1.1.3:

    i) The long-term impacts (assessed as an annual average) of both SO_2 and NO_2 are at low levels compared to the AQ standards and we do not consider this to be an issue.

    ii) The short-term impacts are more difficult to assess. The AQ standards relate to exceedences in a year, and H1 is only appropriate to give a rough indication of issues. Further, H1 is very pessimistic for emissions from a combustion plant. The PCER shows NO_2 as particularly significant.

1067 We used our internal screening model to give a more accurate assessment of AQ impacts. We used inputs of 1.91 g s^{-1} for SO_2 and 33.81 g s^{-1} for NO_2 (the emission rates for one EDG) and assumed 88 hours of operation in a year for the annual average. The maximum concentrations were found at a distance of about 400 m:

a) annual average SO_2 = 0.01 µg m^{-3} – not significant against our environmental assessment level of 50 µg m^{-3};

b) annual average NO_2 = 0.16 µg m^{-3} – not significant against the environmental quality standard of 40 µg m^{-3};

c) 99.9^{th} percentile 15 minute mean SO_2 = 15.9 µg m^{-3} – not significant against the environmental quality standard of 266 µg m^{-3} not to be exceeded more than 35 times a year;

d) 99.97^{th} percentile 1 hour mean NO_2 = 101.4 µg m^{-3} – significant against the environmental quality standard of 200 µg m^{-3} not to be exceeded more than 18 times a year but possibly tolerable depending on background levels of NO_2 at a specific site and allowing for infrequent operation.

e) One respondent queried our use of the SO_2 environmental assessment level (EAL) of 50 µg m^{-3}. This is our published EAL [H1 – Environment Agency, 2010e] for humans. There are National objectives for the protection of vegetation and ecosystems:

   i) Annual mean NO_2 = 30 µg m^{-3};

   ii) Annual mean SO_2 = 20 µg m^{-3}.

   We use these objectives when considering sensitive habitats – again the impact from the EDGs should not be significant against these.

1068 The operator will need to provide site-specific modelling to demonstrate compliance with AQ standards at sensitive locations as part of the permit application. The modelling will need to include any effects on dispersion from the large nuclear power plant buildings near by.

1069 EDF and AREVA show an understanding of the requirements of the Environmental Permitting Regulations. There are issues for an operator to resolve at the site-specific stage, such as BAT for the diesel engines and a demonstration that the short- term impact of the emissions of NO_2 does not compromise AQ standards. Nevertheless, in principle and without prejudice to our formal determination of an application in due course, we believe we can issue a permit for the operation of the stand-by diesel generators.

1070 The operator will need to identify any Natura 2000 sites near a specific site. We will then determine whether the Habitats Regulations are relevant to the specific site and need to be considered in our determination of a permit. We have not assessed this matter at GDA.

1071 West Somerset Council and Sedgemoor District Council (GDA155) provided some detailed comments, copied below:

'*The authorities concerns in relation to non-radioactive polluting substances relate primarily to the potential effects on noise, air quality and waste, as a result of construction and operation of reactors. With regards to noise, we are concerned at the potential levels of noise that may be associated with some aspects of design. In particular, operation of diesel generators (para 701(h)) we fully agree that intermittent noise, as would be associated with generator tests and use, can have its own particular issues. In addition to the suggested requirement for demonstrating BAT, at a local level the proximity of potential receptors and the effect of intermittent noise, in the context of ambient noise levels, should also be taken into consideration.*

With regards to air quality, we also agree that use of diesel generators should also ensure compliance with Environmental Quality Standards. (para 701(l)). With regards to the discussion of the screening approach taken by the EA (para 702) we fully agree with the importance of consideration of air quality at sensitive receptors as part of the Environmental Permit application. We also consider that in addition to consideration of compliance with Environmental Quality Standards, assessment should also reflect the local ambient air quality of sensitive receptors, as both nuclear power stations and sensitive reactors would generally be found in rural location, away from areas of high traffic flow and industrial inputs

We also welcome the suggestion of commitment to a certified environmental management process such as ISO 14001:2004, as a means of management of environmental impacts and demonstrating compliance to local stakeholders.

While not assessed at GDA, paragraph 705 rightly identifies the importance of Natura 2000 sites and their vulnerability to pollution from non-radioactive sources. We note that pollution prevention from non-radioactive substances during *construction of the reactors is not expressly considered within Section 15.3. We would expect the Environment Agency to require full satisfaction that construction activities would similarly not be associated with significant environmental effects on local communities and sensitive receptors. Construction activities would also be required to take full account of the Habitats Regulations.'*

We understand the respondent's concern about construction activities but our powers to control such matters are limited. Construction activities should be covered under the planning process, we will highlight any relevant issues in our role as a statutory consultee.

14.5 Environmental Permitting Regulations 2010 (EPR10): Waste management

14.5.1 Conclusion

1072 Our conclusions are unchanged since our consultation.

1073 **We conclude that EDF and AREVA's strategy and proposals for the management of non-radioactive waste are consistent with:**

a) **the waste hierarchy;**

b) **the Waste Framework Directive objective that waste management is carried out without endangering human health and without harming the environment;**

c) **the requirement of The Environmental Protection Act 1990 (EPA 90) that waste shall not be treated, kept or disposed of in a manner likely to cause environmental pollution or harm to human health;**

d) **the duty of care under EPA 90**.

1074 In addition we note that future operators will need to produce a site waste management plan for each of their construction projects with an estimated cost greater than £300,000 under the Site Waste Management Plans Regulations 2008.

14.5.2 Background

1075 All non-radioactive waste management is subject to the requirements of the Environmental Permitting Regulations and / or certain sections of the Environmental Protection Act 1990 (EPA 90) and, where relevant, the Hazardous Waste Regulations 2005. We, therefore, expect EDF and AREVA's strategy and proposals for non-radioactive waste management to be consistent with:

a) the waste hierarchy (EC, 2008);

b) the objective that waste management is carried out without endangering human health and without harming the environment (EC, 2008);

c) the requirement that waste shall not be treated, kept or disposed of in a manner likely to cause environmental pollution or harm to human health (EPA 90);

d) the duty of care in section 34 (EPA 90)

1076 A number of consultation responses were received in regard to management of non-radioactive waste which are discussed in the relevant parts of this chapter. No questions on non-radioactive waste were raised at our 6 July GDA stakeholder seminar.

1077 We summarise below the information presented in EDF and AREVA's submission on the management of non-radioactive waste. We assessed all this information and used the GDA process of ROs and TQs to query and expand information where necessary.

14.5.3 Management of non-radioactive waste

1078 EDF and AREVA's integrated waste strategy (IWS) outlines their current strategy for managing radioactive and non-radioactive waste produced from the construction, operation and decommissioning of the UK EPR.

1079 EDF and AREVA state in their IWS that the production of waste on a UK EPR will be an inevitable consequence of the construction of a power station and operation and management of the site. However, the design will help reduce arisings at the point of origin, including the careful choice of raw materials. This is discussed for the operational phase of a UK EPR in PCERsc3.3 and for the construction phase in PCERsc4.3.

1080 EDF and AREVA state in their IWS that during construction a wide range of solid waste will be produced as well as excavation spoil. This includes:

a) packaging;

b) chemicals (material coating, surface treatment) and chemical containers;

c) off spec raw material (wood, plastics, metals).

1081 They also state that excavation of the site, including rock crushing and concrete manufacturing, will produce dust and other particulates, and that demolition of existing buildings (if any) will also produce dust.

1082 EDF and AREVA state in their IWS that non-radioactive solid waste is produced during the operation and maintenance of the process plant (for example, the maintenance of pipes and equipment), and also as a result of a number of routine activities (for example, removing algae from the water abstraction structure, maintaining control rooms equipment, activities in the workshops, waste from office work, packaging and from the canteen). The range of waste is very large.

1083 Non-radioactive waste consists of 'industrial waste' (chemical and material additives, effluents, materials), 'inert waste' (rubble) and 'commercial waste' (canteen, office waste). Several of these types of waste will be classed as hazardous under the Hazardous Waste (England and Wales) Regulations 2005 (as amended) and require special storage and treatment arrangements in accordance with the relevant legislation in order to minimise their impact. Hazardous waste includes solids (batteries, aerosol spray cans, electrical equipment), liquids (solvents, oils) and sludge (paint residues, decontamination products). A more detailed identification of the waste with reference to the European Waste Catalogue and the types of waste found on other nuclear power stations is given in PCERsc3.3.

1084 EDF and AREVA claim in their IWS that the non-radioactive solid waste management strategy is designed to comply with the requirements of the Waste Framework Directive as implemented in the UK by the Environmental Permitting Regulations and the Environmental Protection (Duty of Care) Regulations 1991. They state that they will ensure compliance with these regulations by minimising waste production and storing and transferring waste responsibly. They claim that comprehensive waste management procedures will be implemented for all waste streams through the site environmental management system (EMS). We note that the revised Waste Framework Directive has been transposed through the Waste Regulations 2011. These Regulations amend the Environmental Permitting Regulations 2011, and they also contain stand-alone provisions on, for example, the waste hierarchy. We expect future operators to comply with the requirements of current Regulations.

1085 EDF and AREVA state in their IWS that the way that daily operation and maintenance activities are organised on the power station is important in minimising the amount of non-radioactive waste produced. They claim that waste production will be minimised through effectively implementing the waste hierarchy. Where possible, they will re-use potential waste on-site. Where it is technically and economically feasible, potential waste will be recycled. Waste may be sent for energy recovery; it will only be disposed of to landfill or to incinerator as a final option, where no other reasonably practicable option exists. Information on the volumes of waste that are disposed, recycled or recovered at other stations is provided in PCERsc3.3. Waste that is recycled or recovered includes batteries, packaging and mixed metals. EDF and AREVA claim that waste produced from the UK EPR will be recycled where appropriate routes are available in the UK. They note that arisings of non-radioactive waste are largely determined by operational procedures and practices, and are not solely dependent on the design.

1086 The following table (Table 5 in the IWS) gives an estimate of the annual arisings of the main different types of non-radioactive solid waste.

Waste type	**Annual quantity (tonnes)**
Inert waste and commercial waste	470
Hazardous (non-radioactive) waste	100
Total arisings (annual)	570

1087 An individual respondent (GDA25) responded in our consultation saying that it is very important to have a system in which the public is confident in the effectiveness of the system to distinguish between non-radioactive and radioactive waste. We agree with this comment.

1088 Ingleby Barwick Town Council (GDA38) provided the following response: '*One assumes that the waste handling will be executed by a specialist reputable company – there are some who are not!!! If so, all should be well*'. As mentioned above, we expect the non-radioactive waste management to be consistent with the objective that waste management is carried out without endangering human health and without harming the environment (EC, 2008).

1089 Maldon Town Council (GDA51) provided the following response on construction waste: '*We agree with conclusion and note that waste strategy during construction is not mentioned although UK EPR do acknowledge some types of waste they think will be found during construction*'. The Springfields Site Stakeholder Group (GDA96) provided a similar response: '*We agree that any waste generated during construction should be included within the waste hierarchy strategy and covered within site-specific cases*'. EDF and AREVA present data in the PCER (for example volumes of soil and rock to be excavated) which is related to the EPR Flamanville 3 construction, although they acknowledge that the actual figures will be highly site-specific. We have considered these responses on construction waste but we have not identified an assessment finding on this matter as under the provisions of the Site Waste Management Plans Regulation 2008, future operators shall produce a site waste management plan for construction projects with an estimated cost greater than £300,000.

1090 West Somerset Council and Sedgemoor District Council (GDA154) made the following points in response to our consultation:

a) '*The authorities are in general agreement with the principle of management of non-radioactive waste in accordance with the waste hierarchy. While we recognise the approach advocated in paragraph 716 for minimisation through re-use, recycling and energy recovery ahead of landfilling, we consider that at on a site-specific basis, the feasibility of this approach will also rely on the availability of waste management capacity, the location of facilities, and presence of a supply chain*.' We note this comment but this is outside the scope of GDA.

b) ''*Noting the discussion of construction waste provided in paragraph 710 and 712, we also note that discussion in the consultation document focuses on operational waste management above construction waste management, which is expected to result in significantly higher volumes of waste arisings*.' As mentioned above, future operators shall produce a site waste management plan.

1091 Several respondents, including; the Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA67), Springfields Site Stakeholder Group (GDA96), and the Institution of Mechanical Engineers (GDA145) said that they were satisfied with our conclusions on the management of non-radioactive waste. Additionally, NNB Genco (GDA106) and Horizon Nuclear Power (GDA127) who are potential future operators of the UK EPR both responded saying that they welcomed our conclusions.

14.6 Control of Major Accident Hazards Regulations 1999 (COMAH)

14.6.1 Conclusions

1092 Our conclusions remain unchanged since our consultation.

1093 **We conclude that:**

a) **the UK EPR will store hydrazine (a dangerous substance as defined in the COMAH regulations) in quantities exceeding the lower tier COMAH threshold and will, therefore, be a COMAH lower tier installation;**

b) **the EDF and AREVA qualitative assessment that a major accident to the environment involving hydrazine is highly unlikely is reasonable. The operator will need to undertake a more detailed risk assessment before any hydrazine is first stored;**

c) **the operator should be able to demonstrate that all measures necessary to prevent major accidents and limit their consequences to the environment have been taken for a UK EPR installation**.

1094 The above conclusion relates only to the consequences of major accidents to the environment from hydrazine storage. Our partner in the Competent Authority for COMAH regulation, HSE, is responsible for assessing matters relating to impacts on people.

14.6.2 Background

1095 EDF and AREVA estimated the quantities of chemicals potentially to be stored on the site of a UK EPR and compared to the qualifying quantities of named dangerous substances to which COMAH applies (COMAH (Amendment) Regulations 2005). The most significant chemicals are shown below (PCERsc3.3s7.3):

Chemical	Stored quantity (te)	Lower tier threshold (te)	Upper tier threshold (te)
Hydrazine hydrate	1.5	0.5	2
Hydrogen	0.38	5	50
Petroleum spirits (diesel for back-up generators)	770	2,500	25,000

1096 EDF and AREVA, therefore, state that the site of a UK EPR will become a COMAH lower tier installation because of the expected storage quantity of more than 0.5 tonne of hydrazine hydrate. We agree with EDF and AREVA.

1097 Seven respondents agreed with the designation of a UK EPR as a COMAH lower tier installation.

1098 One individual respondent (GDA38) queried the use of hydrazine when other safer oxygen scavengers are available. We only carried out a basic assessment on information presented in GDA to see if COMAH might be applicable. We expect an operator to present more detailed information, including justification for use of hazardous materials, with their site-specific notification.

1099 The Health Protection Agency (GDA88) queried whether all chemicals stored, which fall under the COMAH Regulations had been considered. EDF and AREVA did provide a list of all hazardous chemicals stored in the PCER sub-chapter 3.3 Table 8. Only hydrazine storage quantities exceeded a COMAH threshold but the risks associated with the others listed will need to be examined with the site-specific notification. The HPA also agreed that a detailed risk assessment will need to be available before operations commence.

1100 One individual respondent (GDA56) suggested that there should be a COMAH public consultation. However, the COMAH Regulations do not require this for lower tier installations.

1101 The operator of a lower tier installation needs to notify the Competent Authority (CA)(ourselves and HSE) and prepare a major accident prevention policy (MAPP) before starting operations. The operator also needs to be able to demonstrate to the CA that they have taken all measures necessary to prevent major accidents and limit their consequences to people and the environment. The notification, MAPP and demonstration (usually documentation underpinning the MAPP) will be site-specific issues for the operator and we have not considered at GDA – our main purpose at GDA was to find out if COMAH would apply.

1102 EDF and AREVA also considered the storage quantities of generic categories such as toxic and flammable substances. These are presented in the PCERsc3.3 Table 8. Aggregation of these categories does not exceed any COMAH threshold, so does not affect the lower tier status determined above.

1103 Hydrazine hydrate is used in small quantities as an additive to water in the secondary circuit to consume residual oxygen. It is usually delivered to site as a solution in drums or intermediate bulk containers (IBCs) and transferred, as required, to buffer storage tanks in the injection system. Hydrazine is a named carcinogen in the COMAH Regulations – hence the low threshold values – and its main risk is to the workforce.

1104 Hydrazine hydrate is a liquid and could have a pathway to the sea in an accident through the site drains. It is classified as dangerous to the environment and is toxic to aquatic organisms. However, its toxicity diminishes with concentration, it is not very bio-cumulable and tends to decompose in the aquatic environment.

1105 EDF and AREVA claim that the UK EPR will contain preventative measures to avoid accidental pollution of the aquatic environment:

a) all containers or tanks will be bunded;

b) any failure of a bund or spillage outside a bund would be collected by the SiteLWDS drain system and held in a discharge storage tank (an ex tank) pending a decision on disposal;

c) hydrazine systems have automatic shut-offs in event of failure.

1106 EDF and AREVA claim that the risk of any hydrazine reaching the sea is very low due to the preventative measures. Also, the low quantity of hydrazine stored and its immediate dilution by the cooling water flow mean that consequences would be very limited. They conclude that a major accident to the environment (MATTE) is highly unlikely from any accident involving hydrazine. We agree with this qualitative risk assessment at this time for GDA. Future operators will need to assess risks in more detail at the site-specific stage in support of their MAPP.

14.7 EU Emissions Trading Scheme

1107 This scheme is one of the policies introduced across the European Union (EU) to help it meet its greenhouse gas emissions reduction target under the Kyoto protocol.

1108 A UK EPR will have 82.4 MW (thermal) of combustion plant (see above) and will be an installation required to hold a greenhouse gas emissions permit. An operator of a specific site will need to obtain such a permit from us before any combustion plant operates.

15 Our decision

1109 We have issued an interim statement of design acceptability (iSoDA) for the UK EPR. This is reproduced at Annex 1. It is valid only, where relevant, only for a site meeting the identified generic site characteristics (see chapter 13.3 above).

1110 We made our decision to issue an iSoDA after we had carefully considered all responses to our consultation.

1111 We are issuing an interim SoDA at this time because we have two GDA Issues:

a) Provide a consolidated Final GDA Submission, including agreed design change for the UK EPR (GI-UK EPR-CC02 revision 3). The Issue reflects that EDF and AREVA will need to continue to control changes to the GDA submission documents, resulting from the management of possible changes to the design, until the issue of final SoDA. Design changes are also possible from resolution of the 31 GDA Issues identified by ONR.

b) Consider and action plans to address the lessons learned from the Fukushima Event (GI-UK EPR-CC03 revision 3)

1112 EDF and AREVA have proposed Resolution Plans to address both GDA Issues, available on the Regulators' joint website (see http://www.hse.gov.uk/newreactors/2011-gda-issues-epr.htm). With ONR, we have reviewed these plans, and consider them credible.

1113 As part of our assessment we identified a number of assessment findings. We expect future operators to address assessment findings during the detailed design, procurement, construction or commissioning phase of any new build project. The assessment findings are introduced in relevant chapters of this document and are shown as a consolidated list in Annex 3.

1114 Chapter 16 in the Consultation Document was our 'Conclusion' and we asked for views on this. Nine respondents generally supported our overall conclusion. Several were confident that the two GDA Issues we had at consultation could be resolved, and these were indeed closed out by additional information as shown earlier in this document.

1115 The Health Protection Agency (GDA88) wished to state that dispersion modelling would be required with permit applications for each site. The HPA '*will provide further comment regarding all aspects of the impact of these discharges to the environment on a case-by-case basis*'.

1116 The Socialist Environment Resources Association (GDA125) considered that '*it is NOT appropriate to issue an interim statement on design acceptability of UK EPR*': '*The technical detail of the submission seems to have eclipsed a fundamental concern about public risk. The summary shows that EDF has presented no documentation in their submission on the impact of new build on the local environment at any of the possible sites. Nor have they made a resolution plan for decommissioning after the 50+ year life span of the plant. (GDA Issues p144) These are inter-generational responsibilities on the companies involved and are made less easy to resolve because the Deep Geological Repository for decommissioned waste has not yet been identified for existing legacy waste, nor the location or ownership of new build waste resolved. As these issues are essential to the well being of local and national communities, through which nuclear materials and waste will travel it is NOT appropriate to issue an interim statement on design acceptability of UK EPR*'. We do not consider actual sites at GDA, only a defined generic site. The impact of radioactive discharges on a specific local environment is a matter for site permitting when future operators will need to provide a detailed assessment on the impact of radioactive discharges on the local environment. Other impacts on the local environment are a matter for planning. We closed out the GDA Issue on decommissioning, see chapter 6.5, and wider issues on the proposed Deep Geological Repository are outside the scope of GDA. We recognise SERA's concerns but do not consider that they should prevent the issue of an iSoDA.

1117 We also asked in Chapter 16 of the Consultation Document (question 17) if anyone had any other comments to make. Additionally a number of people provided responses outside our online question system. Where possible we have put these responses into our system under the appropriate question. Where the response was general or outside a specific question we added as a question 17 response. 71 responses to question 17 can be seen in our summary of responses available at https://consult.environment-agency.gov.uk/portal/ho/nuclear/gda.

1118 We are pleased that several respondents found our assessment '*a very professional, thorough report*' (GDA84) and '*robust and thorough*' (GDA96). Overall, responses were generally favourable to the GDA process.

1119 Some respondents were totally averse to building any new nuclear power stations while others believed the UK should build new stations as soon as possible to offset climate change and avoid future power cuts. We only consider in GDA whether a design can meet UK regulatory requirements so these comments were outside our assessment area. The Government has issued '*Meeting the Energy Challenge: A White Paper on Nuclear Power*' (BERR, 2008a).

1120 A number of responses concerned specific sites for building new nuclear power stations. These cannot be dealt with in GDA where we only consider a generic site. We will consider specific site issues when future operators apply to us for permits. We will keep on record responses for specific sites and ensure they are considered in our permit determinations.

1121 We have provided additional comments on responses that were outside the scope of GDA in Annex 8 of this document.

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While every effort has been made to ensure the accuracy of the references listed in this report, their future availability cannot be guaranteed.

List of abbreviations

AGR	Advanced gas-cooled reactor
BAT	Best available techniques
BWR	Boiling Water Reactor
C&I	Control and Instrumentation
COMAH 99	Control of Major Accident Hazards Regulations 1999 (amended 2005)
CSTS	Coolant Storage and Treatment System
CVCS	Chemical and Volume Control System
DAC	Design acceptance confirmation (by ONR)
DECC	Department of Energy and Climate Change
EA 95	Environment Act 1995
EAL	Environmental Assessment Level
EDG	Emergency diesel generator
ENSREG	European Nuclear Safety Regulatory Group
EPA 90	Environmental Protection Act 1990
EPR 10	Environmental Permitting (England and Wales) Regulations 2010
EPRB	GDA UK EPR – BAT demonstration, document UKEPR-0011-001
EPRB 3.5s1.2	EPRB form 3.3 section 1.2 (example reference)
EPRI	Electrical Power Research Institute – an independent USA organisation
EQS	Environmental Quality Standard
ETB	Effluent Treatment Building (this is also referred to as the 'Waste Treatment Building')
ExLWDS	Additional liquid waste discharge system
FAPs	Fission and Activation Products
GDA	Generic design assessment
GWPS	Gaseous Waste Processing System
HEPA	High efficiency particulate air
HLW	High level waste
HPA-RPD	Health Protection Agency – Radiation Protection Division
HSE	Health and Safety Executive
HVAC	Heating, ventilation and air conditioning system
IAEA	International Atomic Energy Agency
iDAC	Interim Design acceptance confirmation
ILW	Intermediate level waste
INSA	Independent Nuclear Safety Assessment
IPR	Independent Peer Review

ISF	Interim Storage Facility
iSoDA	Interim Statement of Design Acceptability
IWS	GDA UK EPR – Integrated Waste Strategy Document UKEPR-0010-001 Issue 00
JPO	Joint Programme Office
LLW	Low level waste
LLWR	Low level waste repository
LoC	Letter of Compliance
LRMDS	Liquid radwaste monitoring and discharge system
LWPS	Liquid Waste Processing System
NDA	Nuclear Decommissioning Authority
NVDS	Nuclear Vent and Drain System
OCNS	Office for Civil Nuclear Security (now Civil Nuclear Security, part of the Office for Nuclear Regulation)
ONR	Office for Nuclear Regulation, an Agency of the HSE (formerly HSE's Nuclear Directorate)
P&ID	Process and information document
PCER	Pre-Construction Environmental Report
PCERsc3.3s4.1	PCER sub-chapter 3.3 section 4.1 (example reference)
PCSR	Pre-Construction Safety Report
PPC	Pollution Prevention and Control
PQAB	Project Quality Assurance Plan
PWR	Pressurised water reactor
QA	Quality Assurance
QMS	Quality Management System
QNL	Quarterly Notification Level
RBWMS	Reactor Boron and Water Make-up System
RCCA	Rod Cluster Control Assemblies
RCS	Reactor Coolant System
REPs	Radioactive substances regulation environmental principles
RI	Regulatory Issue
RO	Regulatory Observation
RSA 93	Radioactive Substances Act 1993
RWMD	Radioactive Waste Management Directorate (of NDA)
SiteLWDS	Site liquid waste discharge system
SBO	Station Black Out
SDM	System Design Manual
SG	Steam Generator

SML	Submission Master List
SoDA	Statement of Design Acceptability
SSER	Safety, Security and Environment Report
TQ	Technical Query
US NRC	United States Nuclear Regulatory Commission
VCT	Volume Control Tank
WRA 91	Water Resources Act 1991

Glossary

Activation product: a material that has been subject to a neutron flux and has been made radioactive as a result.

Alpha activity: some radionuclides decay by emitting alpha particles which consist of two neutrons and two protons.

Assessment finding: Other issues / findings identified during the Regulators' GDA assessment, but not considered critical to the decision to start nuclear island safety-related construction of such a reactor. The findings will be included in ONR's GDA Step 4 Reports or the Environment Agency's GDA Decision Document. They will need to be addressed, as normal regulatory business, either by the designer or by a future Operator/Licensee, as appropriate, during the design, procurement, construction or commissioning phase of the new build project.

Becquerel: the standard international unit of radioactivity equal to one radioactive transformation per second.

- megabecquerel (MBq) – one million transformations per second
- gigabecquerel (GBq) – one thousand million transformations per second
- terabecquerel (TBq) – one million million transformations per second

Best available techniques (BAT): 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*:*

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

b. technological advances and changes in scientific knowledge and understanding;

c. the economic feasibility of such techniques;

d. time limits for installation in both new and existing plants;

e. the nature and volume of the discharges and emissions concerned

Beta activity: some radionuclides decay by emitting a beta particle. This has the same properties as an atomic electron. If the particle carries a positive charge it is known as a "positron".

Collective dose: the dose received by a defined population from a particular source and can apply to public or worker exposure. It is a derived quantity from the addition of the dose received by each individual in the population, and is expressed in units of man-sieverts (manSv) and sometimes in the unit of person sievert Collective dose can be used to represent the total radiological consequences of the source on a population, over a certain period of time. For public impact assessment this is usually 500y and in some cases over all time. The main purpose of collective dose is to allow comparison of radiological impact from source management options and therefore there are no collective dose limits or constraints. Further information on impact can be obtained by conversion to annual average individual doses within a population group. Calculated average annual individual doses for a population group in the nanosievert (nSv/y) range or below can be ignored in the decision-making process as the associated risks are minuscule and the contribution to total doses to individuals will be insignificant. Higher annual doses, up to say a few microsievert (μSv/y) can be considered trivial but may require some consideration particularly if at the higher end of the range.

Critical group: a group of members of the public whose radiation exposure is reasonably similar and is typical of people receiving the highest dose from a given source. This term is being replace by representative person.

Crud: term used to refer to minute, solid, corrosion products that travel into the reactor core, become highly radioactive, and then flow out of the reactor into other systems in the plant. Crud can settle out in crevices or plate-out on the inside of piping in considerable quantities. The major components of crud are iron, cobalt, chrome, and manganese. Crud is a concentrated source of radiation and represents a significant radiological risk because of its insolubility. Crud can be a particular problem if it deposits on fuel pins.

Decommissioning: the process whereby a facility, at the end of its life, is taken permanently out of service and its site is made available for other purposes.

Direct radiation: radiation received directly from a source such as a nuclear power station, instead of indirectly as a result of radioactive discharges.

Discharge: the release of aerial or aqueous waste to the environment.

Disposal: includes:

- placing solid waste in an authorised land disposal facility without plans to retrieve it at a later time
- releases to the environment (emissions and discharges) of gaseous waste (gases, mists and dusts) and aqueous waste
- transfer of waste, together with responsibility for that waste, to another person.

Dose: a general term used as a measure of the radiation received by man and usually measured in sieverts.

Dose constraint: a restriction on annual dose to an individual from a single source, applied at the design and planning stage of any activity. The dose constraint places an upper bound on the outcome of any optimisation study.

Dose limit: the UK legal dose limit for members of the public from all man-made sources of radiation (other than from medical exposure) is 1 mSv y^{-1}.

Final SoDA: The Statement of Design Acceptability provided when all GDA Issues have been addressed to the satisfaction of the Environment Agency.

Fission: splitting of atomic nuclei.

Fission products: radionuclides produced as a result of fission.

Gamma radiation: some radionuclides emit gamma radiation when they decay (usually accompanied by emission of an alpha or beta particle). A gamma ray is a discrete quantity of electromagnetic energy without mass or charge.

GDA Issue: Unresolved issues considered by Regulators to be significant, but resolvable, and which require resolution before nuclear island safety-related construction of such a reactor could be considered. Where there are GDA Issues, the Design Acceptance Confirmation or Statement of Design Acceptability would be designated as ‘Interim’, and the Regulators will expect the RPs to produce a Resolution Plan which identifies how the Issues would be addressed.

GDA Submissions: These include the totality of documents presented to Regulators in GDA, including the Design Reference, the GDA Safety, Security and Environmental Submissions and related supporting references.

GDA Master Document Submission List: This is a 'live' document that documents precisely what GDA submissions have been made, at any one point in time.

Generic Site Envelope: The Requesting Party specified generic siting characteristics for a range of UK sites against which the Regulators assess the acceptability of the design safety case. These characteristics, such as seismic hazard, extreme weather events, environmental receptors, etc., should, so far as possible, envelop or bound the characteristics of any potential UK site so that the reactors could potentially be built at a number of suitable UK locations.

High level waste (HLW): waste in which the temperature may rise, as a result of its radioactivity, to an extent that it has to be accounted for in designing storage or disposal facilities.

Interim SoDA: An interim Statement of Design Acceptability while there are remaining GDA Issues

Intermediate level waste (ILW): waste with radioactivity levels exceeding the upper boundaries for low level waste but which does not require heat generation to be accounted for in the design of disposal or storage facilities.

Low level waste (LLW): waste containing levels of radioactivity greater than those acceptable for disposal with normal refuse but not exceeding 4 GBq/tonne alpha-emitting radionuclides or 12 GBq/tonne beta-emitting radionuclides.

MCERTS: the Environment Agency's Monitoring Certification Scheme. It provides the framework for businesses to meet our quality requirements for monitoring. There are existing MCERTS standards on liquid effluent flow and automatic sampling of liquid effluents which are relevant to nuclear sites and we are developing a new MCERTS standard on radioanalysis of waters.

Man-sievert (personSv): a measure of collective dose.

Nuclear safety related construction: This relates to construction of the main nuclear island, which includes the main reactor building and nuclear auxiliary buildings (such as diesel generator buildings) but does not include, for example, sea defences or the cooling water pump houses that are located away from the nuclear island.

Radioactive waste: has the meaning given in the Environmental Permitting Regulations 2010.

Radioactivity: the property of some atomic nuclides to spontaneously disintegrate emitting radiation such as alpha particles, beta particles and gamma rays.

Radiological assessment: an assessment of the radiation dose to members of the public, including that from discharges, which will result from operation or decommissioning of a facility.

Radionuclide: a general term for an unstable atomic nuclide that emits ionising radiation.

Regulatory Issue: in the judgement of the Regulators, a finding or concern for which, for the design submitted and the mode of operation proposed, the requesting party has not demonstrated (or may not be able to demonstrate) that risks will be reduced as low as reasonably practicable (ALARP), or that regulatory requirements are met, or that the best available techniques (BAT) will be used to minimise the arisings and impact of conventional and radioactive waste, and which is important enough that it would prevent successfully completing GDA or lead to issue of a Statement of Design Acceptability (SoDA).

Regulatory Observation (RO): an assessment finding that requires further justification by and / or discussion with the Requesting Party and further assessment by the Regulators in the expectation that it can be resolved to the satisfaction of the Regulators. A Regulatory

Observation that has not been satisfactorily resolved may, at the discretion of a Regulator, be converted to a Regulatory Issue (RI).

Requesting Party (RP): The term used for the company (or companies) that have submitted designs for Generic Design Assessment (GDA) by the nuclear regulators (the Environment Agency, HSE and OCNS (the latter two now being the Office for Nuclear Regulation (ONR)). The Requesting Parties are Electricité de France SA and AREVA NP SAS for the UK EPR^{TM}, and Westinghouse Electric Company LLC for the AP1000® design.

Sievert (Sv): a measure of radiation dose received.

- millisievert (mSv) – one thousandth of a sievert
- microsievert (μSv or microSv) – one millionth of a sievert
- nanosievert (nSv) – one thousandth of one millionth of a sievert.

Stellite: a hard, wear- and corrosion-resistant family of nonferrous alloys of cobalt (20-65%), chromium (11-32%), and tungsten (2-5%); resistance to softening is exceptionally high at high temperature.

Technical Query (TQ): A request for clarification or further information resulting from the inspection / assessment process. A Technical Query is not a Regulatory Observation or a Regulatory Issue, but may result in an Observation or Issue being raised by the Regulators to the Requesting Party where the query cannot be satisfactorily resolved.

Units

MW	megawatt
MWe	megawatt electrical
GBq y^{-1}	gigabecquerels per year
MBq y^{-1}	megabecquerels per year
μSv y^{-1}	microSievert per year
te	tonne

Annex 1 – Interim statement of design acceptability

Generic assessment of candidate nuclear power plant designs

Interim statement of design acceptability for the UK EPR™ design submitted by Electricité de France SA and AREVA NP SAS (EDF and AREVA)

The Environment Agency has undertaken a Generic Design Assessment of the EDF and AREVA UK EPR™ design, during the period July 2007 to June 2011, 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 Decision Document for the Generic Design Assessment of EDF and AREVA's UK EPR[2].

The Environment Agency is satisfied that EDF and AREVA has demonstrated the acceptability for environmental permitting of the UK EPR on the generic site, as defined in Schedule 1, subject to the GDA Issue identified in Schedule 2.

This statement is provided as advice to EDF and AREVA, under section 37 of the Environment Act 1995. It does not guarantee that any site-specific applications for environmental permits for the UK EPR will be successful.

Name	Date
[name of authorised person]	

Authorised on behalf of the Environment Agency

References

1. Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, Environment Agency, January 2007. http://publications.environment-agency.gov.uk/pdf/GEHO0107BLTN-e-e.pdf
2. Decision Document for the Generic Design Assessment of EDF and AREVA's UK EPR™, Environment Agency, December 2011.

Schedule 1 – Scope of the GDA

This interim statement of design acceptability refers to the UK EPR as described in the design reference documentation:

a) *Reference Design Configuration* UKEPR-I-002 Revision 10. EDF and AREVA, May 2011.

b) UK EPR GDA Step 4 *Consolidated Pre-Construction Environment Report*. EDF and AREVA, March 2011, as detailed in EDF and AREVA letter UN REG EPR00998N 18 November 2011.

c) The documents identified in the Submission Master List: *UK EPR GDA Submission Master List*. UKEPR-0018-001 Issue 01, EDF and AREVA, 18 November 2011.

Certain aspects have been agreed as being out of scope for GDA and these are identified by EDF and AREVA in the Reference Design Configuration document at a) above.

Schedule 2 – GDA Issues

<table>
<tr><td colspan="4">EDF AND AREVA UK EPR GENERIC DESIGN ASSESSMENT
GDA ISSUE
CONSOLIDATED FINAL GDA SUBMISSION INCLUDING AGREED DESIGN CHANGE FOR THE UK EPR
GI-UKEPR-CC-02 REVISION 3</td></tr>
<tr><td colspan="2">Technical Area</td><td colspan="2">CROSS CUTTING</td></tr>
<tr><td colspan="2">Related Technical Areas</td><td colspan="2">All</td></tr>
<tr><td>GDA Issue Reference</td><td>GI-UKEPR-CC-02</td><td>GDA Issue Action Reference</td><td>GI-UKEPR-CC-02.A1</td></tr>
<tr><td>GDA Issue</td><td colspan="3">EDF and AREVA to continue to control, maintain and develop the GDA submission documentation, including the Safety, Security and Environment Report (SSER), Submission Master List (SML) and design reference document and deliver final consolidated versions of these as the key references to any Design Acceptance Confirmation (DAC) / Statement of Design Acceptability (SoDA) the Office for Nuclear Regulation (ONR) or Environment Agency (the joint Regulators) may issue at the end of GDA. These should include the management and acceptance of changes to GDA submission documentation impacted by design changes agreed for inclusion in GDA.

This GDA Issue is raised by both ONR and Environment Agency.</td></tr>
<tr><td>GDA Issue Action</td><td colspan="3">EDF and AREVA to fully implement its processes to manage the implementation and acceptance of amendments to documentation impacted by design changes agreed for inclusion in GDA, including any other additionally agreed design changes associated with other GDA Issues Resolution Plans. This should involve the incorporation of all relevant amendments into the impacted documentation associated with design changes, including the Reference Design Configuration Document UKEPR-I-002, the Pre-Construction Safety Report (PCSR), and the Pre-Construction Environment Report (PCER).

Evidence we expect to see to address this action includes:
Revision of GDA submission documentation impacted by design changes agreed for inclusion in GDA and scheduled to be updated before the end of GDA; in particular, amendments to submission level 2 design information such as System Design Manuals (SDMs) impacted by design changes agreed for inclusion in GDA.
Acceptance by EDF and AREVA of amendments to submission level 2 design change documentation provided by a GDA supplier (for example SOFINEL as a supplier of amended SDMs)
Completion of Independent Nuclear Safey Assessment (INSA) and Independent Peer Review (IPR) where applicable and incorporation of Design Safety Review Committee (DSRC) recommendations into the GDA submission documentation, where appropriate, for any</td></tr>
</table>

<table>
<tr><td colspan="4">EDF AND AREVA UK EPR GENERIC DESIGN ASSESSMENT
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<tr><td></td><td colspan="3">design changes agreed for inclusion in GDA.
• Application of appropriate surveillance arrangements for suppliers/contractors used for the products.
To facilitate our assessments and our inspections in this area the programme of deliverables of amended impacted design change documentation will need to include sufficient time for us to complete our assessments before we may issue any DAC/SoDA.
With agreement from the joint Regulators this action may be completed by alternative means.</td></tr>
</table>

<table>
<tr><td colspan="4">EDF AND AREVA UK EPR GENERIC DESIGN ASSESSMENT
GDA ISSUE
CONSOLIDATED FINAL GDA SUBMISSION INCLUDING AGREED DESIGN CHANGE FOR THE UK EPR
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<tr><td colspan="2">Related Technical Areas</td><td colspan="2">All</td></tr>
<tr><td>GDA Issue Reference</td><td>GI-UKEPR-CC-02</td><td>GDA Issue Action Reference</td><td>GI-UKEPR-CC-02.A2</td></tr>
<tr><td>GDA Issue Action</td><td colspan="3">EDF and AREVA to apply the revised Design Change procedure in order to identify and transfer all relevant agreed incomplete GDA design changes into Nuclear Site Licensing and permissioning activities, and Environmental Permitting.

Evidence we expect to see provided to address this action includes:

• Examples of application of arrangements for transfer of incomplete GDA design changes into Nuclear Site Licensing and Environmental Permitting activities.

With agreement from the joint Regulators this action may be completed by alternative means.</td></tr>
</table>

<table>
<tr><td colspan="4">EDF AND AREVA UK EPR GENERIC DESIGN ASSESSMENT
GDA ISSUE
CONSOLIDATED FINAL GDA SUBMISSION INCLUDING AGREED DESIGN CHANGE FOR THE UK EPR
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<tr><td>GDA Issue Reference</td><td>GI-UKEPR-CC-02</td><td>GDA Issue Action Reference</td><td>GI-UKEPR-CC-02.A3</td></tr>
<tr><td>GDA Issue Action</td><td colspan="3">EDF and AREVA shall continue to control, maintain and develop the GDA submission documentation, including the SSER, SML and design reference document and shall deliver final consolidated versions of these as key references to any DAC/SoDA we may issue at the end of GDA.

Evidence we expect to see to address this action:
Application of EDF and AREVA due processes, including QA and technical reviews for the control and development of the GDA submission documentation scheduled to be created or updated before the end of GDA and contained within the SSER, SML and design reference document to address GDA Issue resolution, agreed design changes, and any other updates agreed with the joint Regulators.
Application of EDF and AREVA due processes, including technical reviews, INSA and IPR where applicable and QA consolidation checks on final GDA submission documentation scheduled to be created or updated before the end of GDA and contained within the SSER, SML and design reference document. The final GDA submission documentation is to be referenced from any DAC/SoDA we may issue. The evidence should include:
Management and incorporation of all review comments and DSRC recommendations in the final consolidated documentation as necessary.
The full assessment of impacts arising from proposed modifications or changes in specific topic areas, including consequential impacts across the SSER.
Delivery of final consolidated GDA submission documentation scheduled to be created or updated before the end of GDA including SSER, SML and design reference document in good time for regulatory assessment prior to any decisions to issue DAC/SoDA that would reference these documents
With agreement from the joint Regulators this action may be completed by alternative means.</td></tr>
</table>

EDF AND AREVA UK EPR GENERIC DESIGN ASSESSMENT GDA ISSUE CONSIDER AND ACTION PLANS TO ADDRESS THE LESSONS LEARNT FROM THE FUKUSHIMA EVENT GI-UKEPR-CC-03 REVISION 3			
Technical Area		**CROSS CUTTING**	
Related Technical Areas		**All**	
GDA Issue Reference	**GI-UKEPR-CC-03**	**GDA Issue Action Reference**	**GI-UKEPR-CC-03.A1**
GDA Issue	**EDF and AREVA are required to demonstrate how they will be taking account of the lessons learnt from the unprecedented events at Fukushima, including those lessons and recommendations that are identified in the HM Chief Inspector's interim and final reports.**		
GDA Issue Action	EDF and AREVA to address the lessons learnt from their internal review following the Fukushima event relevant to GDA for the UK EPR. Evidence we expect to see provided to address this action includes: 1) Internal review summary report 2) A plan for the necessary actions arising from the internal review report 3) Modification of the following, as appropriate: a. Design Reference and SSERs b. Submission Master List documentation (Levels 1-3), including amendments to submission level 2 design information such as SDMs in accordance with GDA Issue GI-UKEPR-CC.02 c. Resolution Plans in response to other relevant GDA Issues 4) Confirmation that any design changes resulting from these reviews for inclusion into GDA will be managed in accordance with the UK EPR GDA Project Procedure UKEPR-I-003. With agreement from the Regulators this action may be completed by alternative means.		

EDF AND AREVA UK EPR GENERIC DESIGN ASSESSMENT GDA ISSUE CONSIDER AND ACTION PLANS TO ADDRESS THE LESSONS LEARNT FROM THE FUKUSHIMA EVENT GI-UKEPR-CC-03 REVISION 3			
Technical Area		**CROSS CUTTING**	
Related Technical Areas		**All**	
GDA Issue Reference	**GI-UKEPR-CC-03**	**GDA Issue Action Reference**	**GI-UKEPR-CC-03.A2**
GDA Issue	**EDF and AREVA are required to demonstrate how they will be taking account of the lessons learnt from the unprecedented events at Fukushima, including those lessons and recommendations that are identified in the HM Chief Inspector's interim and final reports.**		
GDA Issue Action	EDF and AREVA to address the lessons learnt that are relevant to GDA for UK EPR from HM Chief Inspector Nuclear Installations' interim and final reports. Evidence we expect to see provided to address this action includes: 1) A Plan to address the relevant actions arising from HM Chief Inspector's interim and final reports. 2) Modification of the following, as appropriate: a. Design Reference and SSERs b. Submission Master List documentation (Levels 1-3), including amendments to submission level 2 design information such as SDMs in accordance with GDA Issue GI-UKEPR-CC.02 c. Resolution Plans in response to other relevant GDA Issues 3) Confirmation that any design changes resulting from these reviews for inclusion into GDA will be managed in accordance with the UK EPR GDA Project Procedure UKEPR-I-003. With agreement from the Regulators this action may be completed by alternative means.		

Annex 2 – Compilation of assessment findings

We require the future operator, to address the following assessment findings during the detailed design, procurement, construction or commissioning phase of any new build project.

Reference	Assessment finding
UK EPR-AF01	The future operator shall, at the detailed design stage, identify any changes to the 'reference case' for solid radioactive waste and spent fuel strategy, and provide evidence that the site-specific integrated waste strategy (IWS) achieves the same objectives.
UK EPR-AF02	The future operator shall, at the detailed design stage, provide an updated decommissioning strategy and decommissioning plan.
UK EPR-AF03	Future operators shall keep the removal of secondary neutron sources (to further minimise creation of tritium) under review. EDF and AREVA should provide future operators with relevant EPR operational information when available to facilitate their reviews of BAT
UK EPR-AF04	Future operators shall, during the detailed design phase for each new build project, review BAT on minimising the production of activated corrosion products for the following matters, where possible improvements were identified in the PCER: i) corrosion resistance of steam generator tubes; ii) electro-polishing of steam generator channel heads; iii) specification of lower cobalt content reactor system construction materials; iv) further reducing use of stellites in reactor components, in particular the coolant pump. Where appropriate, any improvements considered BAT should be incorporated into the new build.
UK EPR-AF05	Future operators shall, before the commissioning phase, provide their proposals for how they intend to implement zinc injection. The proposals shall be supported by an assessment of the impact of zinc injection on waste and crud composition.
UK EPR-AF06	Prior to construction of the conventional and nuclear island liquid effluent discharge tank systems, future operators shall demonstrate that site-specific aspects such as size and leak-tight construction techniques are BAT.
UK EPR-AF07	Future operators shall, before the commissioning phase, provide an assessment to demonstrate that proposed operational controls on the fuel pool are BAT to minimise the discharge of tritium to air.

Reference	Assessment finding
UK EPR-AF08	Future operators shall, during the detailed design phase, provide their proposals for the operational management of the Liquid Waste Processing System to minimise the discharge of radioactivity from the site so that exposures of any member of the public and the population as a whole are kept as low as reasonably achievable (ALARA) and to protect the environment. The proposals should be supported by a BAT assessment to show that the use of the evaporator, the choice of filter porosity and the demineralisation media have been optimised to minimise the dose to members of the public. The future operator shall also provide evidence that the Water Treatment Systems have sufficient capacity and resilience to cope with all the aqueous radioactive waste arisings consigned to the evaporator by the proposals. The proposals should consider all plant states, including for example outages and unavailability due to maintenance or breakdown.
UK EPR-AF09	Future operators shall, during the detailed design stage, provide a predicted mass balance showing how their proposed aqueous radioactive waste management regime will affect the disposal of carbon-14 to the gaseous, solid or aqueous routes. For each route the form of carbon-14 expected shall be provided. For solid wastes the quantities of each type of waste shall be provided with expected carbon-14 content.
UK EPR-AF10	The future operator shall provide confidence that adequate radioactive waste management cases (RWMCs), supported by appropriate stage Letters of Compliance (LoCs), can be developed for all intermediate level waste (ILW) on the timescales identified in EDF and AREVA's plan for disposability of ILW
UK EPR-AF11	The future operator shall provide evidence during the detailed design phase that the proposed specific techniques for preventing and, where that is not possible, minimising the creation of low level waste (LLW) and intermediate level waste (ILW) are the best available techniques (BAT).
UK EPR-AF12	The future operator shall provide evidence during the detailed design phase that the proposed specific techniques for treating and conditioning of low level waste (LLW) and intermediate level waste (ILW) before disposal are the best available techniques (BAT).
UK EPR-AF13	If smelting of any low level waste (LLW) is pursued, the future operator shall demonstrate that the conditions of acceptance of the selected smelting facility can be met.
UK EPR-AF14	If incineration of any low level waste (LLW) is pursued, the future operator shall demonstrate that the conditions of acceptance of the selected incineration facility can be met.
UK EPR-AF15	If incineration of any intermediate level waste (ILW) is pursued, the future operator shall demonstrate that the conditions of acceptance of the selected incineration facility can be met.

Reference	Assessment finding
UK EPR-AF16	The future operator shall, before the commissioning phase, propose techniques for the interim storage of spent fuel following a period of initial cooling in the pool. The future operator shall provide an assessment to show that the techniques proposed are BAT.
UK EPR-AF17	The future operator shall, before the commissioning phase, provide confidence that adequate Radioactive Waste Management Cases (RWMCs), supported by appropriate stage Letters of Compliance (LoCs) and taking due account of necessary storage periods, can be developed for spent fuel on the timescales identified in EDF and AREVA's plan for disposability of spent fuel.
UK EPR-AF18	Future operators shall provide: c) during the detailed design phase, the location and arrangement of sampling and continuous monitoring facilities for gaseous and aqueous wastes supported by an assessment that these will provide representative sampling and monitoring; d) during the detailed design phase and before final equipment selection, the details of equipment and techniques to be used for analysis of gaseous, aqueous and solid wastes supported by an assessment that these represent BAT for monitoring.

Annex 3 – Final assessment reports

Document reference	**Generic design assessment** **UK EPR nuclear power plant design by Electricité de France SA and AREVA NP SAS** **Final assessment report -**
EAGDAR UKEPR-01	Management Systems
EAGDAR UKEPR-02	Integrated Waste Strategy
EAGDAR UKEPR-03	Best Available Techniques to prevent or minimise the creation of radioactive wastes
EAGDAR UKEPR-04	Gaseous radioactive waste disposal and limits
EAGDAR UKEPR-05	Aqueous radioactive waste disposal and limits
EAGDAR UKEPR-06	Solid radioactive waste (LLW and ILW)
EAGDAR UKEPR-07	Spent Fuel
EAGDAR UKEPR-08	Disposability of ILW and Spent Fuel
EAGDAR UKEPR-09	Monitoring of radioactive disposals
EAGDAR UKEPR-10	Generic site
EAGDAR UKEPR-11	Radiological impact on members of public
EAGDAR UKEPR-12	Radiological impact on non-human species
EAGDAR UKEPR-13	Other Environmental Regulations
IMAS/TR/2010/05 EAGDAR UK EPR-14	Independent dose assessment

Annex 4 – UK EPR: range of discharges from operating PWRs

A4.1 Introduction

1122 The White Paper on Nuclear Power (paragraph 2.87) states that 'The Environment Agencies will ensure that radiation exposure of members of the public from disposals of radioactive waste, including discharges, are as low as reasonably achievable (ALARA) by requiring new nuclear installations to use the best available techniques (BAT) to meet high environmental standards. This will help ensure that radioactive wastes created and discharges from any new UK nuclear power stations are minimised and do not exceed those of comparable power stations across the world.'

1123 Industrial processes produce waste and power generation is no exception. Although nuclear power stations produce far less gaseous waste than conventional power stations, they produce radioactive waste not only in gaseous waste but in aqueous and solid waste as well.

1124 By gaseous waste we mean contaminated air, particulate, gases and vapours released from the reactor or areas where contaminated materials or waste are handled. Aqueous radioactive waste may be reactor coolant or other effluent, for example, from workshops handling contaminated plant and equipment or change areas. Solid waste may be contaminated having been in contact with reactor plant and equipment.

1125 This annex covers only low level radioactive waste, it does not cover higher activity waste or irradiated nuclear fuel.

1126 Since the beginning of nuclear power generation, Regulators have required operators of nuclear power stations to take samples, carry out measurements and assessments and determine radioactivity in discharges.

1127 These measurements and assessments are particularly valuable in determining what the impact on our environment is and whether there is any impact on the food chain.

1128 Knowing what radioactive waste was discharged from operational stations also allows us to consider whether technology can be used to minimise the amount of waste from new stations.

1129 Radioactivity in waste is not just affected by technology used to minimise it. Improvements in reactor design lead to more efficient burn-up of the nuclear fuel, so less radioactive waste is produced for each unit of electricity generated. Other aspects of reactor design can lead to less radioactivity in waste, for example selecting materials, coolant flow rates and operating conditions.

1130 This annex is in two parts: firstly a section covering the discharges from operating reactors that are immediate predecessors to the EPR to compare the discharges per unit of electricity with those claimed for the EPR; secondly a wider view of a larger number of operating PWRs that compares the long-term average discharges normalised to installed electrical capacity. Some of the average data in the second section includes contributions from reactors in the first section.

1131 Radioactive waste from nuclear power stations contains a wide range of radionuclides. We talk about harm from radioactivity in terms of radiation dose. Some radionuclides are more important than others as they may lead to higher radiation dose. We consider the half life of a radionuclide, its chemical and physical form, its behaviour in the environment and other properties when assessing radiation dose.

A4.2 Radionuclides produced in low level radioactive waste from nuclear power stations

1132 The major radionuclides or groups of radionuclides produced are:

a) tritium – a low energy beta emitting radionuclide with a half-life of 12.3 years. It absorbs through pores in the skin as tritiated water;

b) carbon-14 - a low energy beta emitter with a very long half-life. It can be taken up by crops and marine life;

c) noble gases – xenon and krypton radionuclides formed by fission (and less importantly argon-41). The highest contributor to the group is xenon-133 with a half-life of 5.25 days. Noble gases are beta and gamma emitters. They neither impact on the food chain nor are absorbed by lungs. The exposure route to members of the public is directly by radiation from the plume. This is a trivial route of exposure for discharges from water cooled reactors;

d) iodines – several radionuclides of iodine are formed during nuclear fission. The most important of these is iodine-131, with a relatively short half-life of 8 days, it is both a beta and gamma emitter. The main pathway for dose to the public is by being deposited on crops and then eaten, for example deposited on grass, grazing by cows, then consumption of contaminated milk;

e) other radionuclides – we have grouped other radionuclides produced together as they tend to be minimised by the same techniques (for example filtration or ion exchange) and are usually measured as a group using a gross activity method. The most important of these are:

    i) cobalt-60 and cobalt-58, these are activated corrosion products with half-lives of 5.3 years and 71 days respectively. They are both beta and gamma emitters.

    ii) caesium-137 and caesium-134, these are fission products with half-lives of 30 and two years respectively. They are both beta and gamma emitters.

f) cobalt-60 is the most significant of these radionuclides in terms of radiation dose to the public from aqueous discharges from water cooled reactors. Cobalt-60 has a medium length half-life. It can accumulate in marine sediments on which, fish and shellfish live and pass to humans who consume seafood;

g) a number of other activated corrosion products can also be produced in less significant amounts. These radionuclides include iron-55 and nickel-63.

A4.3 Section One - Discharges from operating predecessor reactors

1133 We commissioned Areva Risk Management Consulting Ltd to research records of radioactive waste disposal from comparable operating nuclear power stations worldwide. The results of this work are contained in science reports SC070015/SR1 and 2.

A4.3.1 What the science report covered

1134 The science report researched information on four types of candidate reactor:

a) AP1000 submitted by Westinghouse;

b) Evolutionary pressurised reactor, EPR submitted by EDF and AREVA;

c) Economic simplified boiling water reactor, ESBWR submitted by GE-Hitachi;

d) ACR-1000, submitted by AECL.

1135 This annex covers the EPR only.

1136 It provides discharge information from seven stations that are predecessors to the EPR design.

1137 Where discharge information was not provided directly by operators of those nuclear-power stations, it was obtained indirectly from the nuclear Regulators in the country where they were operating or from reports from the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). The report presents the discharges having normalised them to gigabecquerels per gigawatt-hour (GBq/GWeh).

A4.3.2 Discharges from the operational nuclear power stations

1138 The discharge data for the predecessor nuclear power stations allows us to compare and extrapolate so we can predict discharges from candidate nuclear power stations. It is important not to draw comparisons too closely as there are many uncertainties in the datasets. The largest uncertainty is probably differences in sampling and measurement techniques that the predecessor stations evolved and use – these are general improvements in sampling equipment and instrument sensitivity leading to more accurate measurements being carried out.

A4.3.2.1 Gaseous discharges

Table 1: Releases of gaseous waste from operating station

		Gaseous discharge				
	Years	**Tritium (MBq/GWeh)**	**Carbon-14 (MBq/GWeh)**	**Noble Gases (MBq/GWeh)**	**Iodines (kBq/GWeh)**	**Fission and activation products (kBq/GWeh)**
Predecessor actual – **EPR**	’90-‘06	10 - 200	5 – 50	9 - 300	0.006 - 9	0.0003 - 800
Comments		V. low consequences				

A4.3.2.2 Aqueous discharges

Table 2: Releases of aqueous waste from operating stations

	Aqueous release	
	Tritium (GBq/GWeh)	**Other Radionuclides (kBq/GWeh)**
Predecessor actual – **EPR**	0.8 – 4	0.009 - 9000

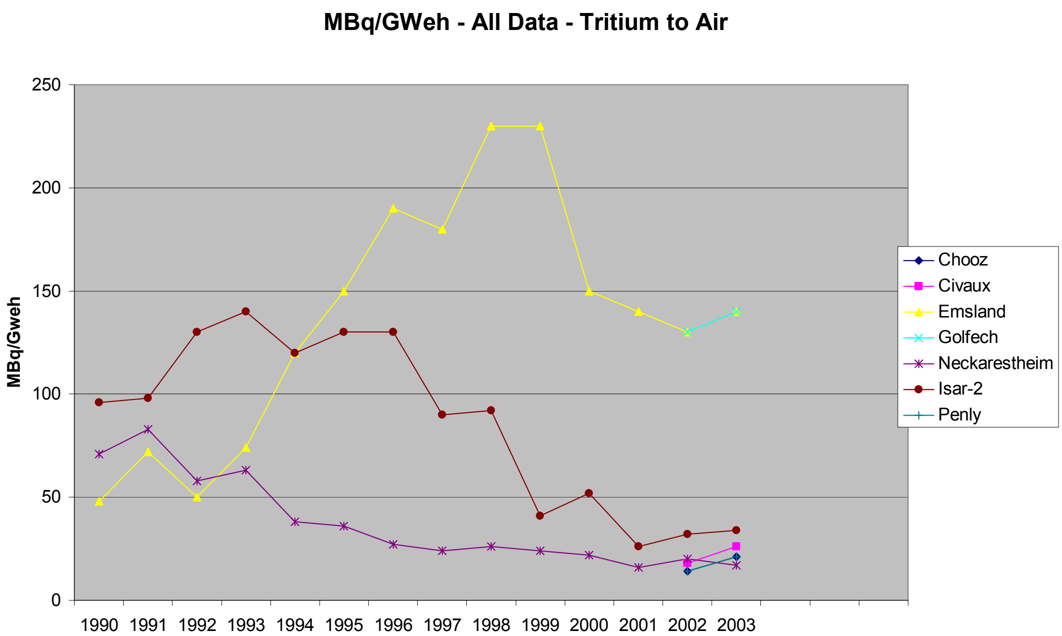
Notes:

1) The ranges presented in tables 1 and 2 represent the range of activity in discharges over the seventeen-year reporting period.
2) The science report breaks down discharges of aqueous waste into two categories – tritium and other.
3) Figures have been rounded to one significant figure.

A4.3.3 EPR PREDECESSOR STATIONS

Gaseous tritium

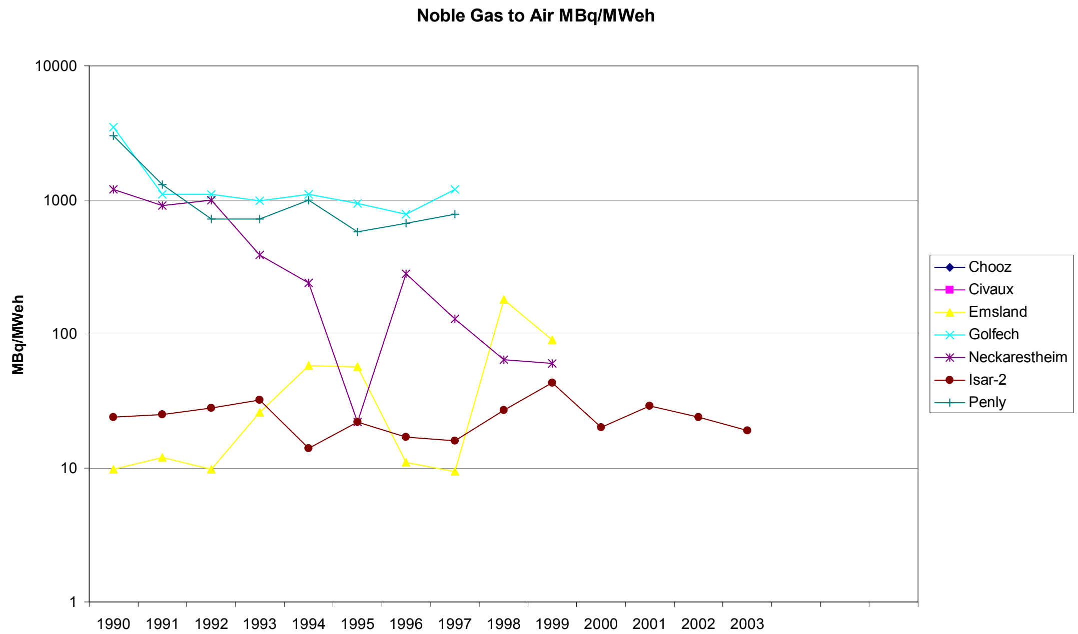
1139 Below is a graph of all of the gaseous tritium discharges for predecessor PWRs to the EPR:



1140 This indicates that 75 per cent of the discharges are within the range 20 -130 MBq/GWeh.

Noble gases

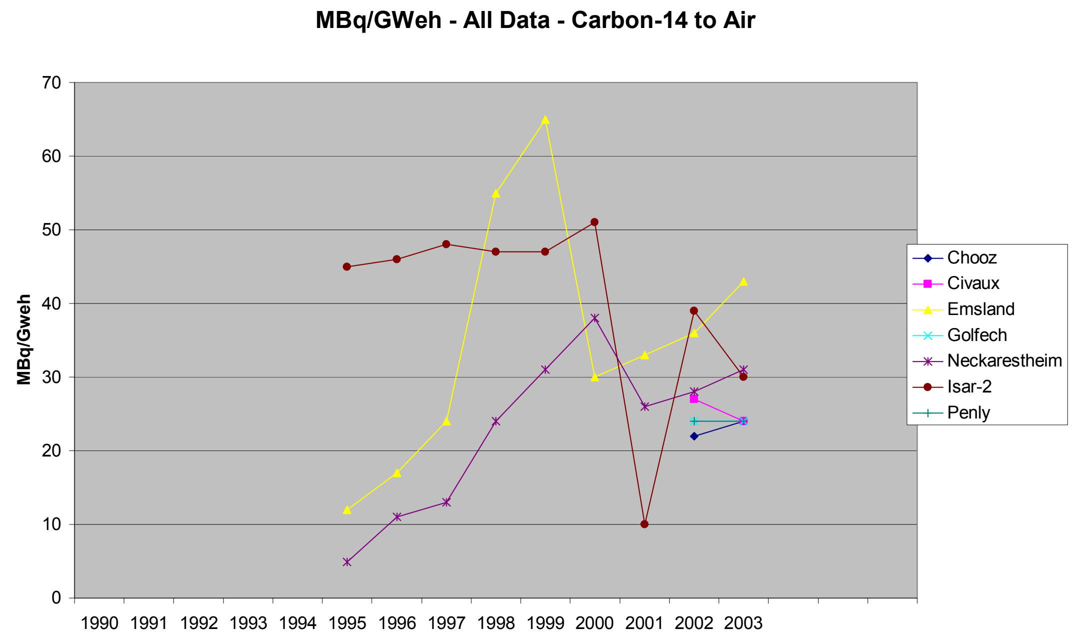
1141 Below is a graph of all of the airborne noble gas discharges for predecessor PWRs to the EPR:



1142 This indicates that 75 per cent of the discharges are within the range 10 -1000 MBq/GWeh.

Carbon-14

1143 Below is a graph of all of the airborne carbon-14 discharges for predecessor PWRs to the EPR:



1144 This indicates that 75 per cent of the discharges are within the range 14 -48 MBq/GWeh.

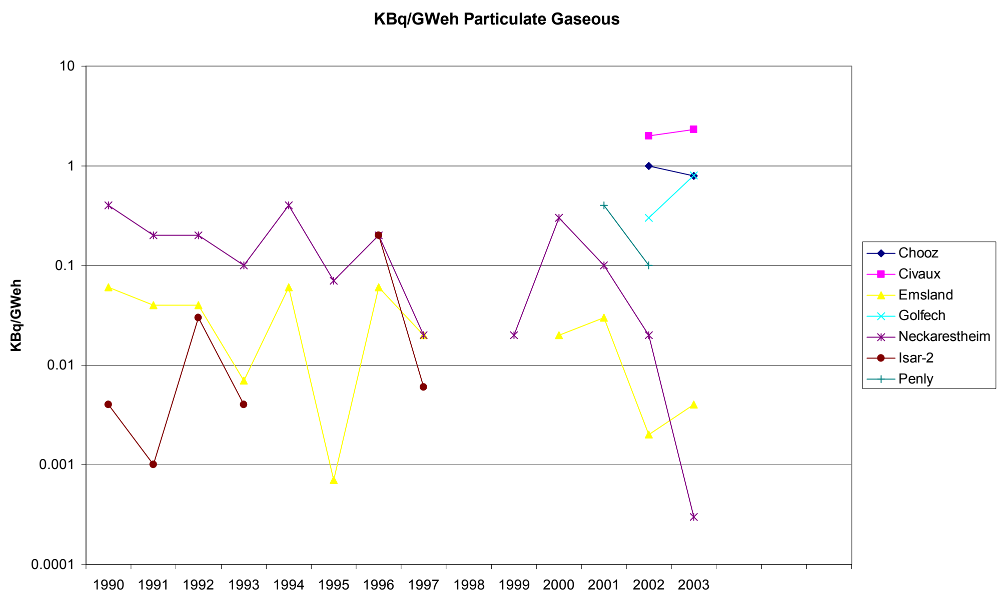
Iodine -131

1145 Below is a graph of all of the iodine-131 gaseous discharges for predecessor PWRs to the EPR:

1146 The data set is comparatively small and indicates that 75 per cent of the discharges are within the range 0.07 -20 kBq/GWeh.

Gaseous particulate

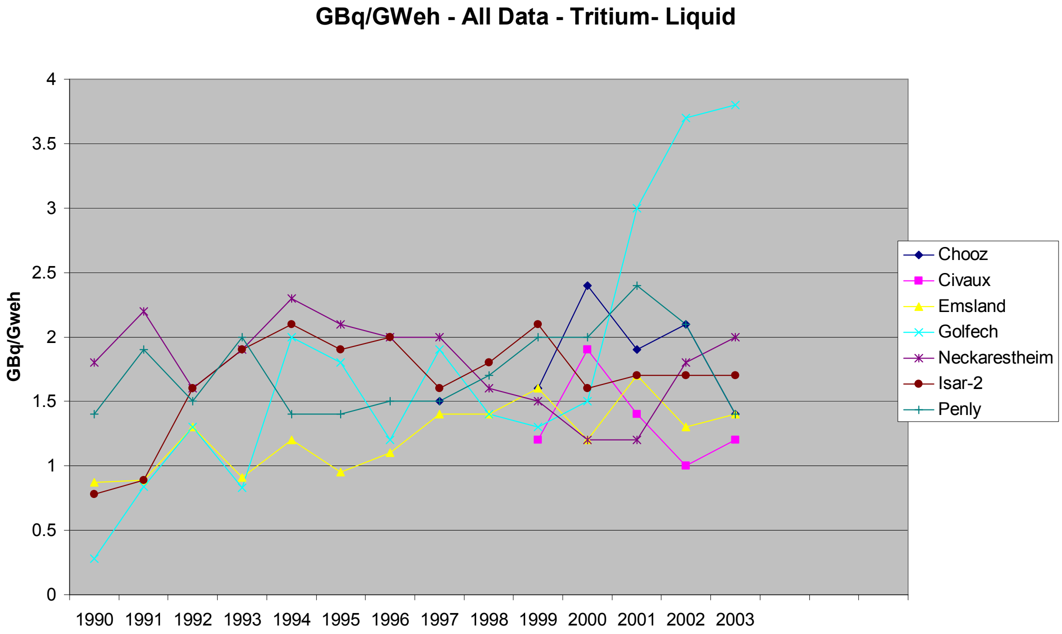
1147 Below is a graph of all of the gaseous particulate discharges for predecessor PWRs to the EPR:



1148 This indicates that 75 per cent of the discharges are within the range 0.01 - 0.3 MBq/GWeh.

Aqueous tritium

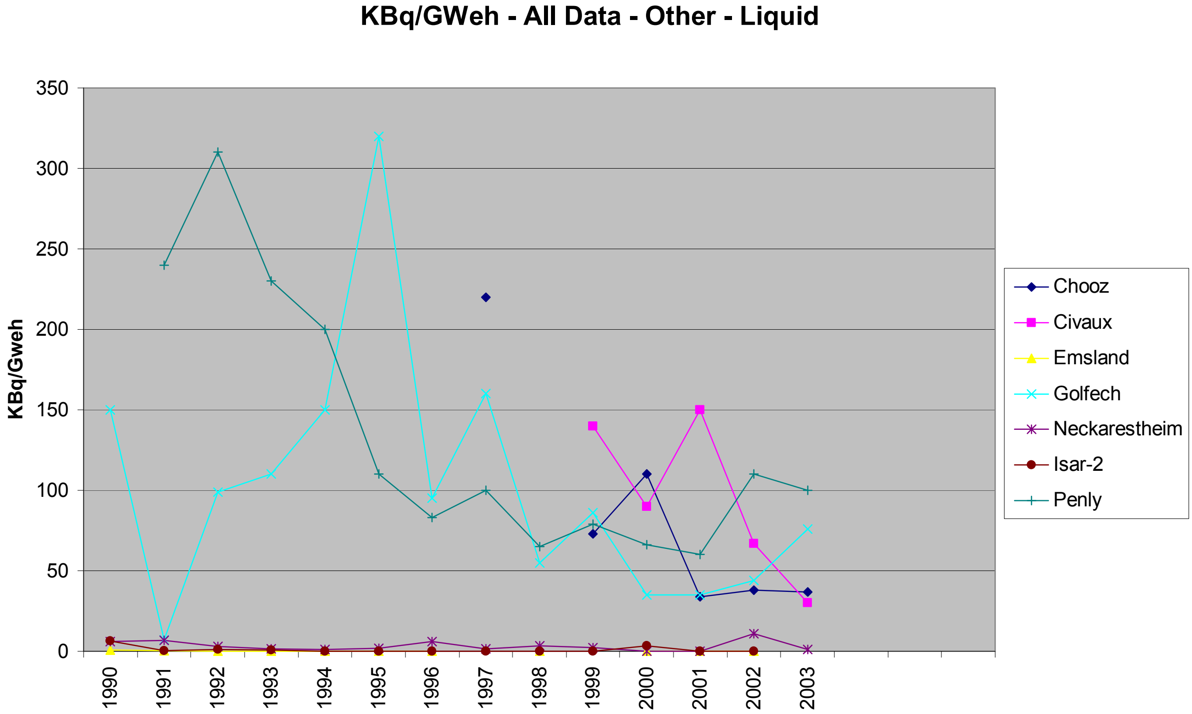
1149 Below is a graph of all of the aqueous tritium discharges for predecessor PWRs to the EPR:



1150 This indicates that 75 per cent of the discharges are within the range 1.2 - 2 GBq/GWeh, which is a relatively narrow range.

Aqueous other radionuclides

1151 Below is a graph of all of the aqueous other radionuclide discharges for predecessor PWRs to the EPR:-



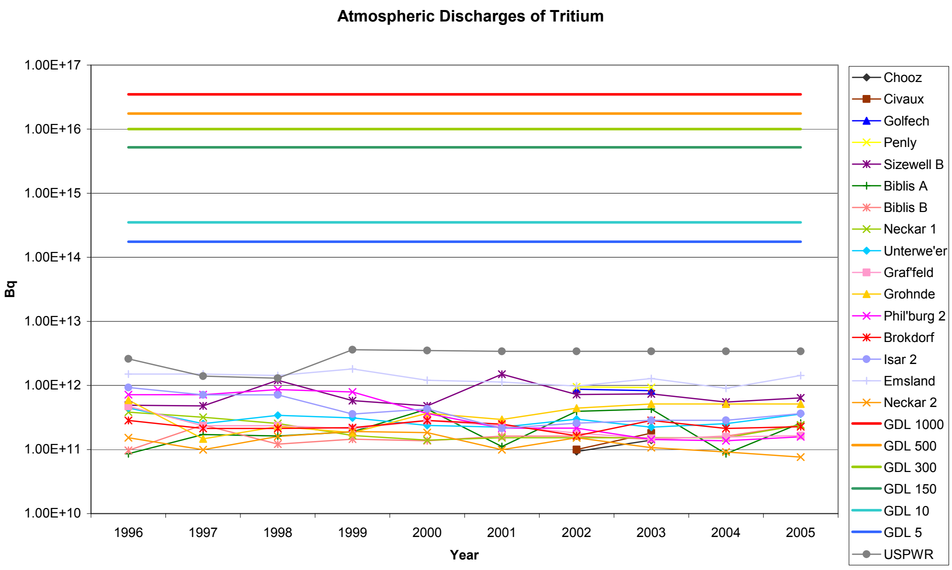
1152 This indicates that 75 per cent of the discharges are within the range 0 – 70 kBq/GWeh, which is a relatively narrow range. This is one of the most diverse ranges of the datasets. Some stations reported discharges at extremely low levels, which indicate that they operate with a much better abatement plant than other stations.

A4.4 Section Two - Average discharges from the wider PWR sector

A4.4.1 Atmospheric discharges

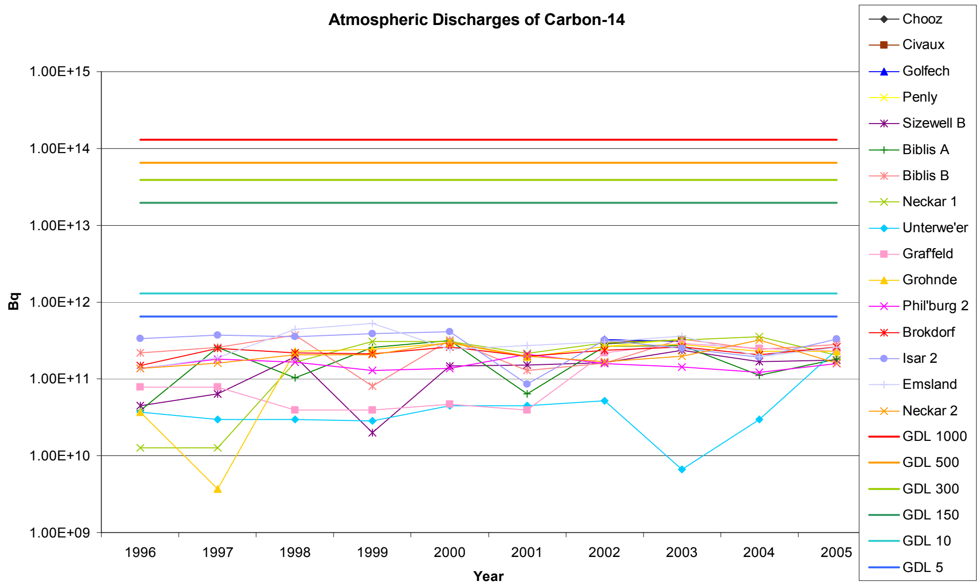
Tritium - Atmospheric discharge

1153 From our examination of historic discharges from European PWRs (References 1 and 3) and US PWRs (Reference 2) operating over the last 10 to 15 years, we conclude that there is a normal operating range of 100 to 3600 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 0.2 μSv. The generalised derived limits (GDL) used in the graph represent the values of discharge leading to doses to the most exposed individual of 1000, 500, 300, 150, 10 and 5 μSv.



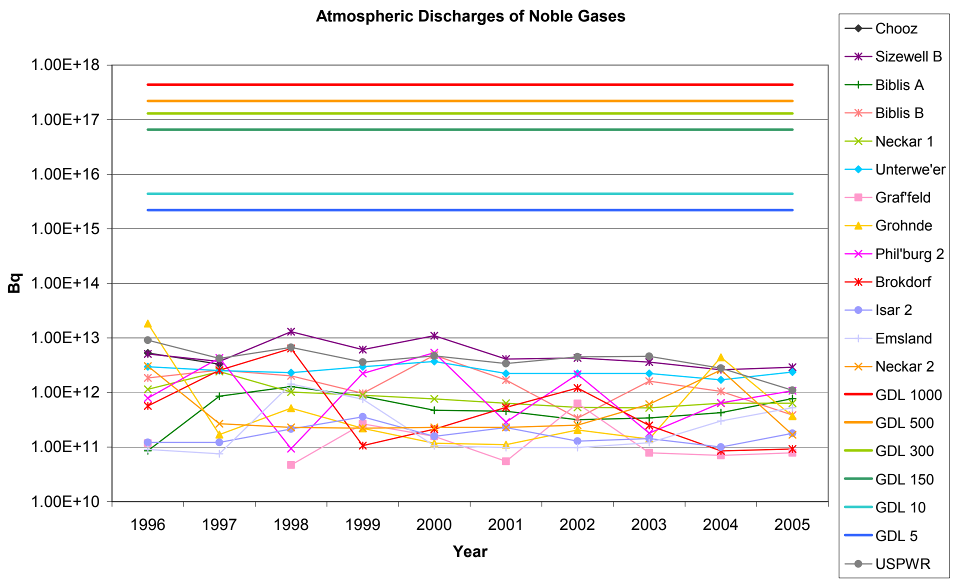
Carbon-14 - Atmospheric discharge

1154 From our examination of historic discharges from European PWRs operating over the last 10 to 15 years (see the graph below), we conclude that there is a normal operating range of 40 to 530 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 3 μSv.



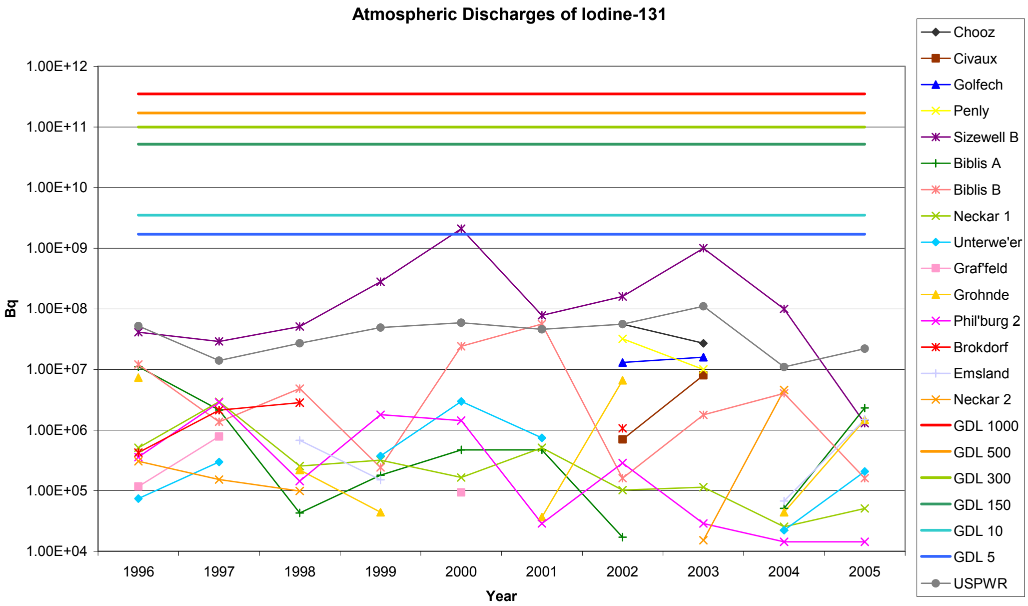
Noble gases - Atmospheric discharge

1155 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years (see graph below), we conclude that there is a normal operating range of 100 to 10 000 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 0.05 μSv (assuming all discharges comprise the most restrictive species krypton-85 - used for the GDL values in the graph).



Iodine - Atmospheric discharge

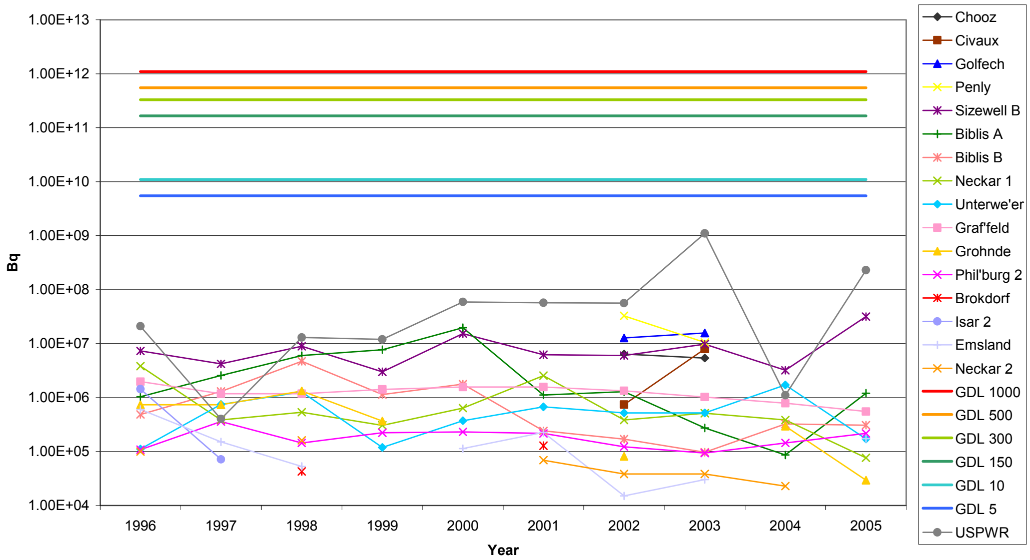
1156 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to atmosphere of iodine-131 there is a normal operating range of from less than 1 to 2000 MBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 0.5 μSv (assuming all discharge to iodine-131).



Fission and activation products - Atmospheric discharge

1157 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to atmosphere of fission and activation products there is a normal operating range of from less than 1 to 1000 MBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 5 μSv (assuming all discharge comprises caesium-137).

Atmospheric Discharges of Fission & Activation Products

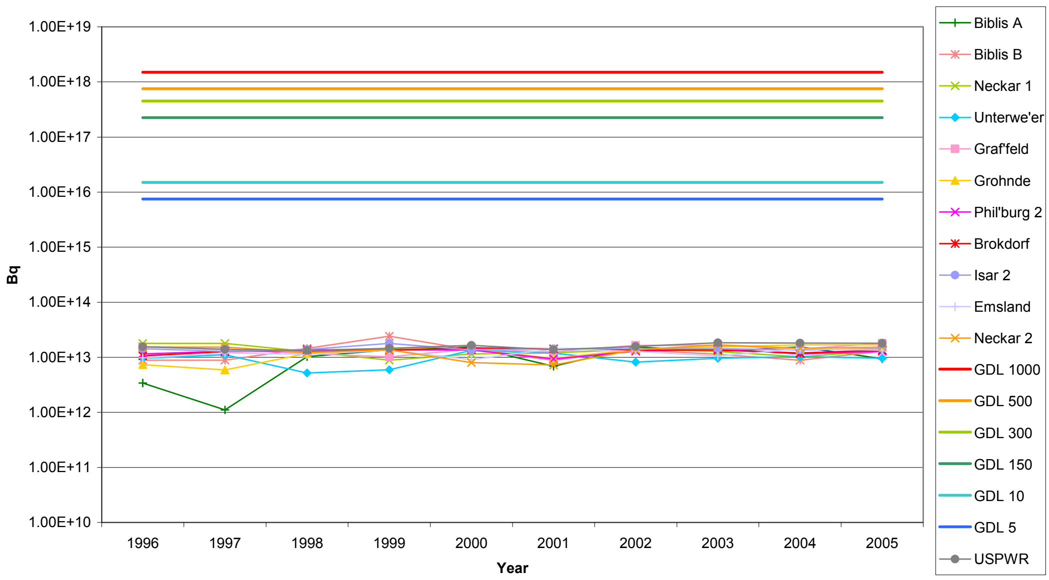


A4.4.2 Aqueous discharges

Tritium - Aqueous discharge

1158 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to water of tritium there is a normal operating range of 2000 to 30 000 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 0.05 μSv .

Aqueous Discharges of Tritium



Carbon-14 - Aqueous discharge

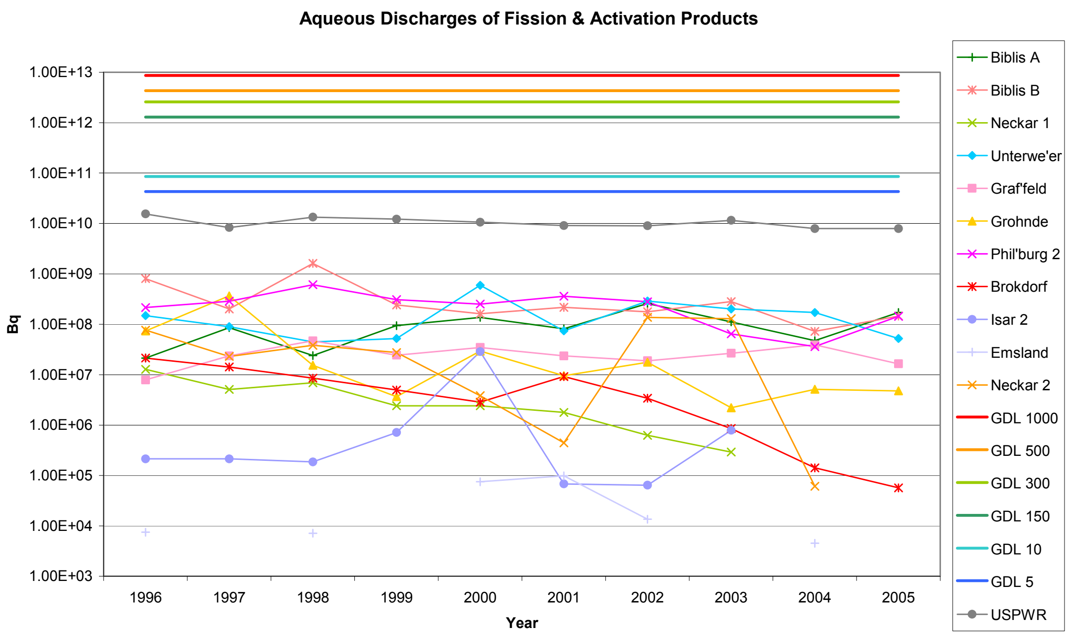
1159 From our limited information about PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to water of carbon-14 there is a normal operating range of 3 to 45 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 20 μSv.

Iodine - Aqueous discharge

1160 From our limited information about PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to water of iodines there is a normal operating range of 0.01 to 0.03 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 0.00006 μSv. Assuming all the iodine is iodine-131.

Fission and activation products - Aqueous discharge

1161 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to water of fission and activation products there is a normal operating range of from less than 1 to 15 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 1 μSv. Assuming all of the discharge is due to caesium-137.



A4.5 Data analysis of normalised discharges from PWR sites

Atmospheric discharges of tritium

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	592 GBq
Median discharge from all sites from 1996-2005	270 GBq
Standard deviation from all sites from 1996-2005	781 GBq
Standard error of the mean from all sites from 1996-2005	67 GBq
Maximum discharge within one year from a single site (USPWR, 1999[12])	3600 GBq
Minimum discharge within one year from a single site (Neckar 2, 2005)	76 GBq

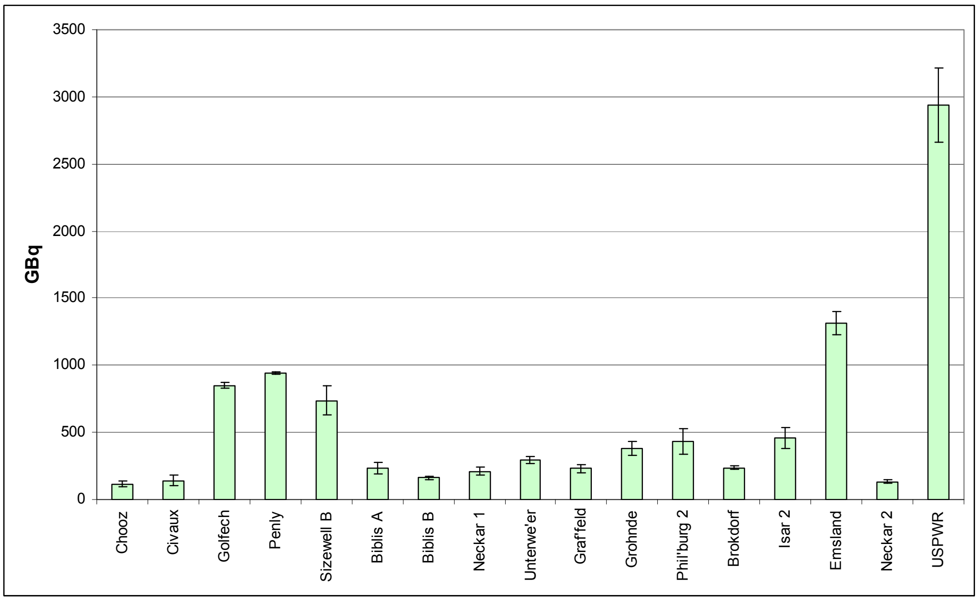


Figure 1: Mean atmospheric discharge of tritium between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

1162 The data for atmospheric discharges[13] of tritium are positively skewed, and, therefore, the median value may be a more accurate parameter than the mean, in terms of indicating future discharges. The graph shows that reported discharges lie within a substantial range over several orders of magnitude. US PWRs report substantially greater discharges than the German and French reactors, as well as Sizewell B.

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[12] USPWR data (United States Pressurised Water Reactor) within this report are the average discharges for that year from the USPWR fleet, and not the discharge of a single site.

[13] Where this section makes reference to 'discharges', this refers to reported discharges which have been normalised to a 1000 MWe reactor, and not actual reported discharges.

Atmospheric discharges of carbon-14

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	202.61 GBq
Median discharge from all sites from 1996-2005	207.22 GBq
Standard deviation from all sites from 1996-2005	108.14 GBq
Standard error of the mean from all sites from 1996-2005	9.56 GBq
Maximum discharge within one year from a single site (Emsland, 1999)	526.71 GBq
Minimum discharge within one year from a single site (Grohnde, 1997)	3.68 GBq

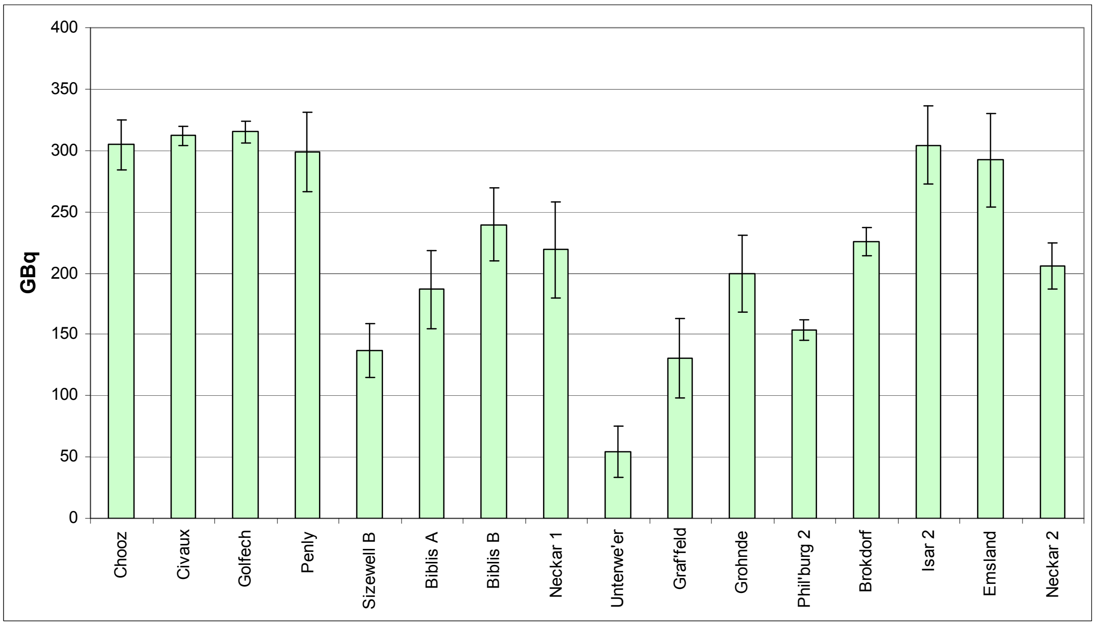

Figure 2: Mean atmospheric discharge of carbon-14 between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

1163 The data for atmospheric discharges of carbon-14 are slightly positively skewed, and, therefore, the median value may be a more accurate parameter than the mean, in terms of indicating future discharges. The chart and table above show that reported discharges lie within a substantial range over several orders of magnitude. French reactors report greater discharges than the German reactors on average, whilst Sizewell B discharges are on average below mean and median discharges from all sites.

Atmospheric discharges of noble gases

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	1801 GBq
Median discharge from all sites from 1996-2005	637 GBq
Standard deviation from all sites from 1996-2005	2635 GBq
Standard error of the mean from all sites from 1996-2005	230 GBq
Maximum discharge within one year from a single site (Grohnde, 1996)	18382 GBq
Minimum discharge within one year from a single site (Graf'feld, 1998)	47 GBq

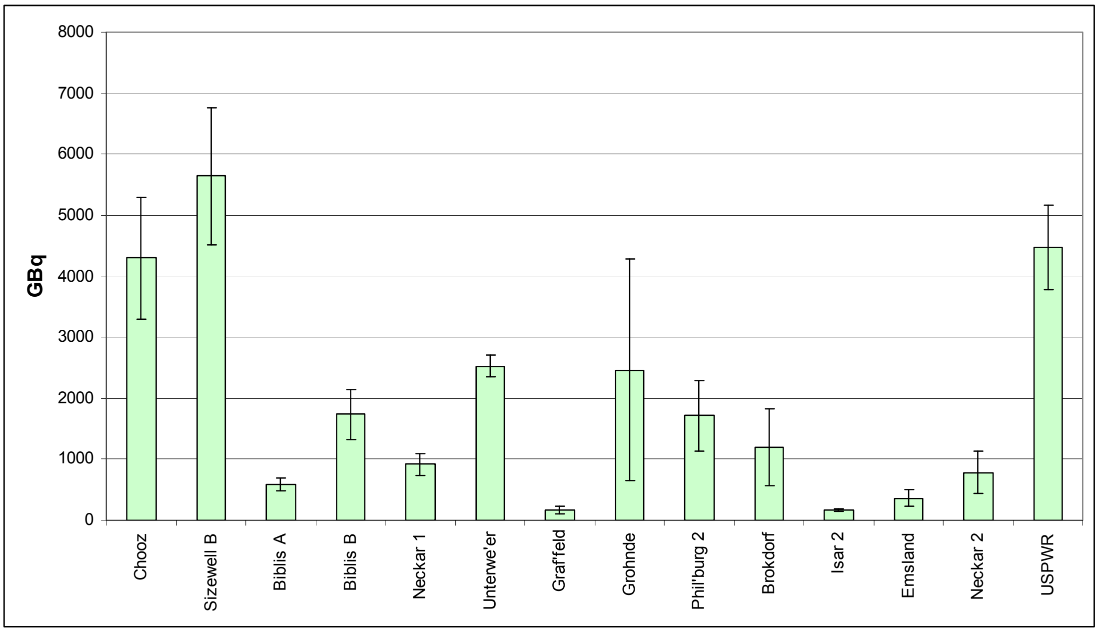

Figure 3: Mean atmospheric discharge of noble gases between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

1164 The data for atmospheric discharges of noble gases are positively skewed, and, therefore, the median value may be a more accurate parameter than the mean, in terms of indicating future discharges. The graph shows that discharges lie within a broad range. The USPWR, Sizewell B and Chooz sites generally report greater average discharges than the German reactors.

Atmospheric discharges of iodine-131

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	0.05 GBq
Median discharge from all sites from 1996-2005	0.0013 GBq
Standard deviation from all sites from 1996-2005	0.24 GBq
Standard error of the mean from all sites from 1996-2005	0.024 GBq
Maximum discharge within one year from a single site (Sizewell B, 2000)	2.10 GBq
Minimum discharge within one year from a single site (Phil'burg, 2005)	0.000014 GBq

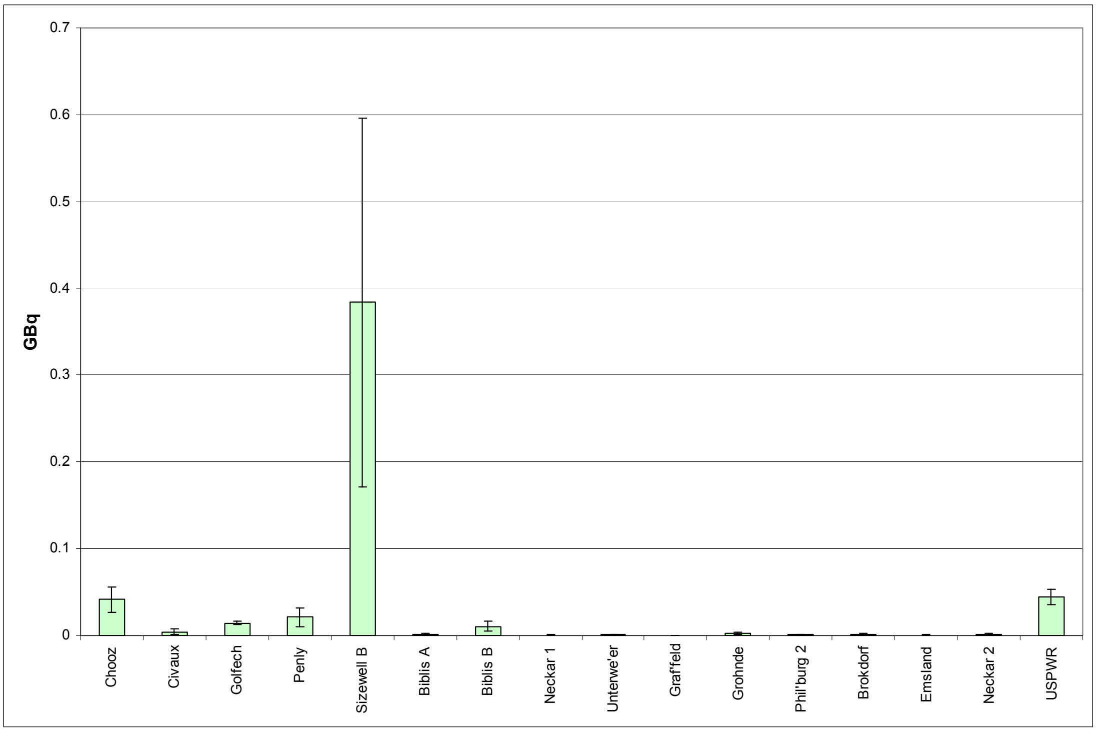

Figure 4: Mean atmospheric discharge of iodine-131 between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

1165 The data for atmospheric discharges of Iodine-131 are positively skewed, and, therefore, the median value may be a more accurate parameter than the mean, in terms of indicating future discharges. The graph shows that average reported discharges from most sites lie well below 0.1 GBq. Average discharges from Sizewell B are substantially greater than the others, which can partially be attributed to two relatively high reported discharges in 2000 and 2003, although discharges from Sizewell B are also generally higher than the other sites. The German reactors typically report lower discharges than the USPWR and French reactor sites.

Atmospheric discharges of fission and activation products

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	0.016 GBq
Median discharge from all sites from 1996-2005	0.00074 GBq
Standard deviation from all sites from 1996-2005	0.11 GBq
Standard error of the mean from all sites from 1996-2005	0.010 GBq
Maximum discharge within one year from a single site (USPWR, 2003)	1.10 GBq
Minimum discharge within one year from a single site (Emsland, 2002)	0.000015 GBq

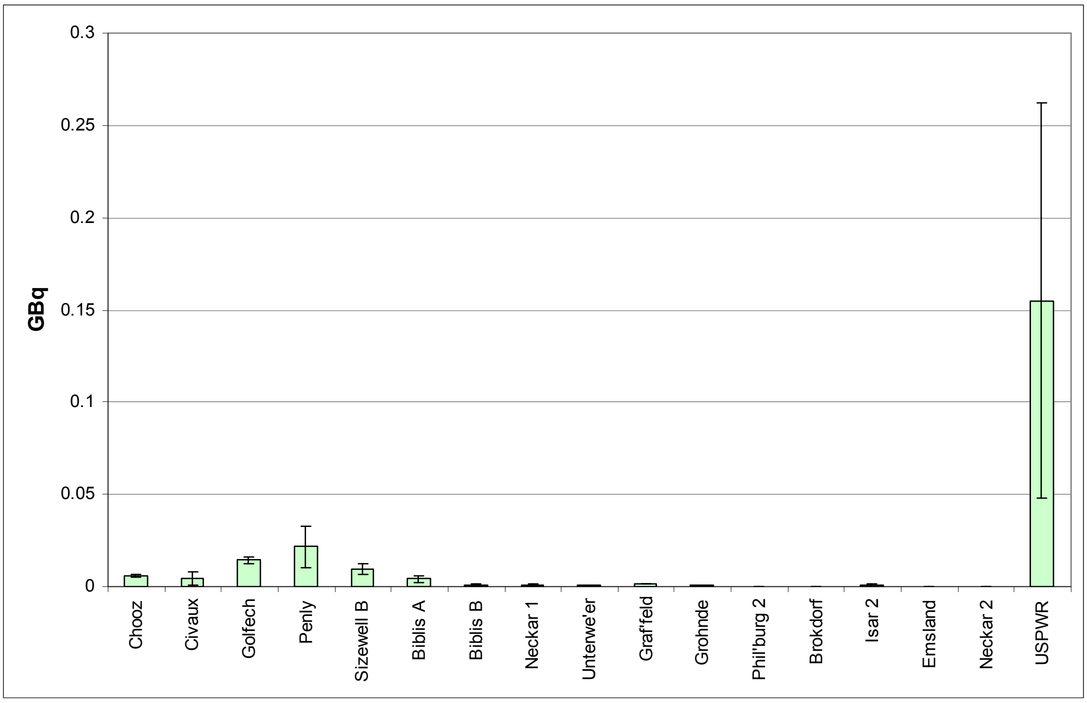

Figure 5: Mean atmospheric discharge of fission and activation products between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

1166 The data for atmospheric discharges of fission and activation products are positively skewed, and, therefore, the median value may be a more accurate parameter than the mean, in terms of indicating future discharges. The graph and table above show that reported discharges lie within a substantial range over several orders of magnitude. The USPWR sites on average report substantially greater discharges than all other sites. The German reactors generally perform better than the French reactors and Sizewell B, in terms of discharges of fission and activation products to the atmosphere.

Aqueous discharges of tritium

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	12817 GBq
Standard deviation from all sites from 1996-2005	3274 GBq
Standard error of the mean from all sites from 1996-2005	299 GBq
Maximum discharge within one year from a single site (Biblis B, 1999)	24194 GBq
Minimum discharge within one year from a single site (Biblis A, 1997)	1114 GBq

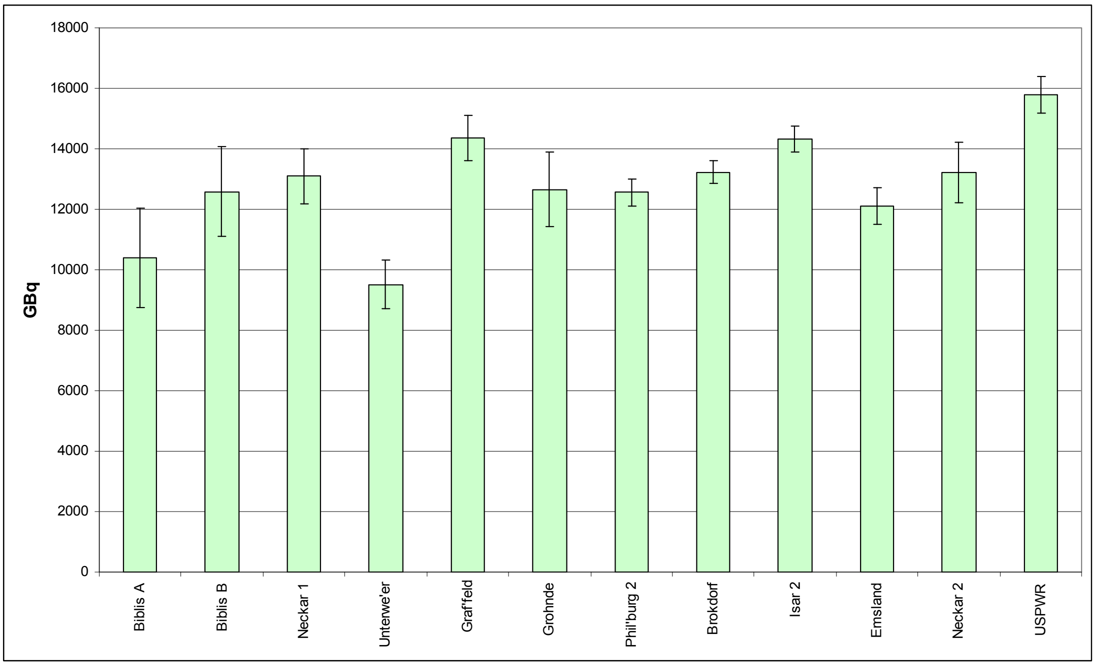

Figure 6: Mean aqueous discharge of tritium between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

1167 The data for aqueous discharges of tritium are normally distributed, and, therefore, the mean value may be a useful indicator of future discharges. The graph shows that reported discharges are relatively stable across all sites, with a relatively small range of discharges and a small margin of error. The USPWR sites on average report slightly greater discharges than the German reactor sites.

Aqueous discharges of fission and activation products

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	1.05 GBq
Median discharge from all sites from 1996-2005	0.04 GBq
Standard deviation from all sites from 1996-2005	3.10 GBq
Standard error of the mean from all sites from 1996-2005	0.29 GBq
Maximum discharge within one year from a single site (USPWR, 1996)	15.50 GBq
Minimum discharge within one year from a single site (Emsland, 2004)	0.0000045 GBq

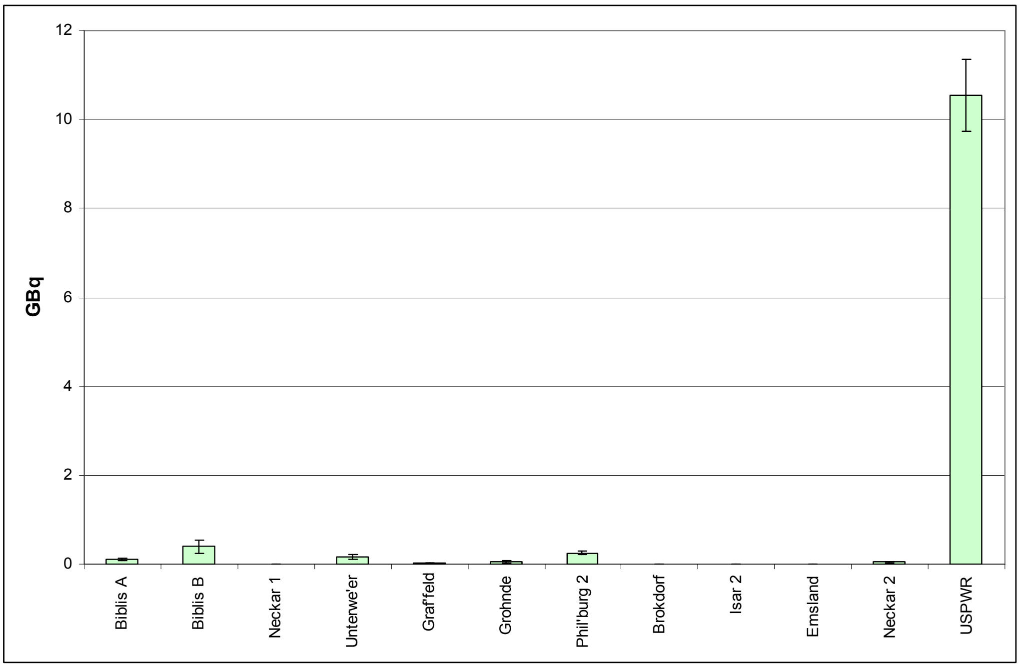

Figure 7: Mean aqueous discharge of fission and activation products between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

1168 The data for aqueous discharges of fission and activation products are positively skewed, and, therefore, the median value may be a more accurate parameter than the mean, in terms of indicating future discharges. The graph and table above show that reported discharges lie within a substantial range over several orders of magnitude. The USPWR sites consistently report substantially greater discharges than the German sites, with a mean discharge of over 10 GBq.

Annex 4 References:

1. Bewertung der epidemiologischenStudiezuKinderkrebs in der Umgebung vonKernkraftwerken (KiKK-Studie) – *Epidemiological study of childhood cancer in the area of nuclear power plants (KiKK study)*. Stellungnahme der Strahlenschutzkommission – *Opinion of the Commission on Radiological Protection* 58, Strahlenschutzkommission (SSK) des BundesministeriumsfürUmwelt, Naturschutz und Reaktorsicherheit – *Radiation Protection Commission (SSK) of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety***.**
2. Radiological Effluents Released by US Commercial Nuclear Power Plants from 1995-2005. Health Physics December 2008, Volume 95, Number 6
3. Environment Agency Science Reports SC070015/SR1 and 2.

Annex 5 – Consultation questions

1169 Below is a list of questions that we had asked for responses to as part of our consultation on the UK EPR design:

1170 Do you have any views or comments on our preliminary conclusions on:

1. management systems?
2. the radioactive waste and spent fuel strategy?
3. best available techniques to minimise the production of radioactive waste?

4a. best available techniques to minimise the gaseous discharge of radioactive waste?

4b. our proposed annual disposal limits?

4c. our proposed gaseous quarterly notification levels?

5a. best available techniques to minimise the aqueous discharge of radioactive waste?

5b. our proposed annual disposal limits?

5c. our proposed aqueous quarterly notification levels?

6. solid radioactive waste?
7. spent fuel?
8. monitoring of disposals of radioactive waste?
9. the impact of radioactive discharges?
10. the abstraction of water?
11. discharges of non-radioactive substances to water?
12. pollution prevention for non-radioactive substances?
13. Environmental Permitting Regulations 2010 (EPR 10) Schedule 1 activities?
14. non-radioactive waste?
15. Control of Major Accident Hazards (COMAH) substances?
16. the acceptability of the design?
17. Do you have any overall views or comments to make on our assessment, not covered by previous questions?

Annex 6 – Criteria for consultation

1171 Our consultation followed the Government's Code of Practice. In particular, we:

a) formally consulted at a stage where there was scope to influence the outcome;

b) consulted for at least 12 weeks with consideration given to longer timescales where feasible and sensible;

c) were clear about the consultation process in the consultation documents, what was being proposed, the scope to influence and the expected costs and benefits of the proposals;

d) ensured the consultation exercise was designed to be accessible to, and clearly targeted at, those people it was intended to reach;

e) kept the burden of consultation to a minimum to ensure consultations were effective and to obtain consultees' 'buy-in' to the process;

f) analysed responses carefully and gave clear feedback to participants following the consultation;

g) ensured officials running consultations were guided in how to run an effective consultation exercise and share what they learnt from the experience.

Annex 7 – Places where consultation documents were advertised or could be viewed and list of respondents

Libraries

1172 A poster advertising the consultation was sent to 1798 local authority run libraries in England and Wales.

1173 A poster advertising the consultation was sent to 743 public sector management libraries in England and Wales.

Print media

1174 An advert was placed in one daily local newspaper in each of the areas around potential new build sites listed in DECC's draft Nuclear National Policy Statement consultation.

1175 An advert was placed in one weekly local newspaper in each of the areas around potential new build sites listed in DECC's draft Nuclear National Policy Statement consultation.

1176 Where possible and when available an advert was placed in local authority magazines which cover areas around potential new build sites listed in DECC's draft Nuclear National Policy Statement consultation.

Environment Agency offices where the documents could be viewed

Environment Agency,
Ghyll Mount
Gillan Way
Penrith 40 Business Park
Penrith
Cumbria
CA11 9BP

Environment Agency
Coverdale House
Aviator Court
Amy Johnson Way
Clifton Moor
York
YO30 4GZ

Environment Agency
Trentside Office
Scarrington Road
West Bridgeford
Nottingham
NG2 5FA

Environment Agency,
Buckley Office
Chester Road
Buckley
CH7 3AJ

Environment Agency
Rivers House
East Quay
Bridgewater
Somerset
TA6 4YS SW

Environment Agency,
Orchard House
Endeavour Park
London Road
Addington,
West Malling
Kent
ME19 5SH

Environment Agency
Kingfisher House
Goldhay Way
Orton Goldhay
Peterborough
PE2 5ZR

List of consultees

1177 We wrote to a wide range of organisations that we believe might be interested in the consultation. A list of these is available upon request.

1178 We also wrote to MPs, MEPs and Welsh AMs and provided information to those who requested it.

1179 Our regional teams developed local engagement plans which we have published on our joint website (www.hse.gov.uk/newreactors/publicinvolvement.htm).

List of respondents

1180 We received 80 responses, of these 54 were from organisations and 26 were from individuals. The responses are listed in the table below, 'ID' is the reference number we assigned to each respondent. We published the text of the responses in December 2010:
(https://consult.environment-agency.gov.uk/portal/ho/nuclear/gda)

Member of Public/Company/Organisation	ID
Arkholme with Cawood Parish Council	GDA46
Blackwater Against New Nuclear Group	GDA112
Bradwell for Renewable Energy	GDA121
Braystones Residents	GDA73
Burneside Parish Council	GDA35
Centre for Environmental Policy, Imperial College, London	GDA84
Committee on Medical Aspects of Radiation in the Environment (COMARE)	GDA129
Communities Against Nuclear Expansion (CANE)	GDA40
Communities Against Nuclear Expansion (CANE)	GDA48
Countryside Council For Wales	GDA143
Cumbria County Council	GDA166
Dept of Agriculture, Belfast	GDA54
English Heritage	GDA63
Forum 21	GDA105
Fylde Borough Council	GDA86
Greater Manchester Socialist Environment Resources Association	GDA125

Member of Public/Company/Organisation	ID
(SERA)	
Greenpeace	GDA151
Health & Safety Executive, Nuclear Directorate	GDA76
Health Protection Agency	GDA88
Horizon Nuclear Power	GDA127
Ingleby Barwick Town Council	GDA38
Institution of Mechanical Engineers	GDA145
Joint Nature Conservation Committee (JNCC)	GDA28
Kent Against a Radioactive Environment (KARE)	GDA147
L2 Business Consulting Limited	GDA123
Low Level Radiation and Health Conference	GDA153
Maldon Town Council	GDA51
Member of Public	GDA158
Member of Public	GDA5
Member of Public	GDA18
Member of Public	GDA19
Member of Public	GDA20
Member of Public	GDA23
Member of Public	GDA25
Member of Public	GDA27
Member of Public	GDA30
Member of Public	GDA32
Member of Public	GDA36
Member of Public	GDA42
Member of Public	GDA52
Member of Public	GDA58
Member of Public	GDA78
Member of Public	GDA92
Member of Public	GDA119
Member of Public	GDA66
Member of Public	GDA62
Member of Public	GDA56
Member of Public	GDA50
Member of Public	GDA44
Member of Public	GDA41
Member of Public	GDA139
Member of Public	GDA135
Member of Public	GDA168
NNB Genco	GDA106

Member of Public/Company/Organisation	ID
Nuclear Consultation Group	GDA149
Nuclear Industry Association	GDA117
Nuclear Legacy Advisory Forum (NuLeAF)	GDA80
Nuclear Technology Subject Group of the Institution of Chemical Engineers	GDA67
Nuclear Waste Advisory Associates (NWAA)	GDA133
Nuclear-Free Local Authorities (NFLA)	GDA82
Parents Concerned About Hinkley	GDA21
People Against Wylfa B (PAWB)	GDA95
RWE NPower	GDA137
Safety and Reliability Society	GDA107
Scottish Power	GDA163
Scottish Water	GDA111
Seafish	GDA90
Sellafield Ltd	GDA126
Shepperdine Against Nuclear Energy (SANE)	GDA114
Shepway District Council	GDA100
Somerset County Council	GDA161
Springfields Site Stakeholder Group	GDA96
Stop Hinkley	GDA157
Studsvik UK Ltd	GDA131
Suffolk Coastal District Council	GDA165
Suffolk County Council	GDA72
Swedish NGO Office for Nuclear Waste Review, MKG	GDA60
Waldringfield Parish Council	GDA102
Welsh Assembly Government	GDA141
West Somerset Council and Sedgemoor District Council	GDA154

Annex 8 – Other consultation comments

Issues raised about multi-reactors sites and cumulative impacts with existing reactors

1181 Some respondents (GDA38, GDA143) were concerned that GDA assessments are based on a single reactor but that, in reality, site-specific proposals will likely be based on more than one reactor, for example there could be two UK EPR or three AP1000 units at a single site. Respondents observed that associated discharges and wastes would need to be scaled up similarly and questioned if this had been taken into account in GDA.

1182 Similarly, some respondents asked about whether cumulative impacts arising from existing nuclear installations adjacent to the new build sites had been assessed in GDA.

1183 Some respondents said that the actual impact can only be assessed when the new reactor is in operation.

Our response

1184 GDA is based on assessing the environment and safety cases of new reactor designs and we chose to base our assessments on a single reactor design because it is the minimum number of of reactors at a station and it represents the underpinning starting point for any station, whether it has one or more reactors. While for a multiple reactor station there will be some opportunities for certain plant and facilities to be shared, much of the design would be replicated for each reactor. It will be for potential operators to define their proposals for specific sites, including the number of reactors that they intend to construct. Potential operators will have to bring forward applications for site-specific permits based on the level of discharges that they expect and consideration of what is best available techniques (BAT) for the site-specific design they propose. These applications would be informed by GDA submissions and assessments and the specific environmental characteristics of the site proposed to be developed. The site-specific characteristics that would have to be addressed in potential operators' assessments include the possibility of cumulative impacts arising from other facilities in the vicinity of the proposed development. We assess and report the radiological impact of existing nuclear facilities in the UK in the Radioactivity in Food and the Environment Report (the RIFE report) that we currently publish annually (see http://www.food.gov.uk/science/surveillance/radiosurv/rife/)

1185 It is normal practice to carry out impact assessments using models and predictions of performance for new reactor designs, not least because no EPR reactors are yet operating. The assessments we have used are based in part on actual experience of other similar reactors already in operation, but there will be uncertainties with regard to the performance of any new reactor. A key requirement of our environmental permits is that operators of nuclear power stations must carry out extensive environmental monitoring programmes. These help to ensure that the impacts are well characterised and reasonably consistent with projections.

Regulatory justification

1186 Some respondents (for example GDA82) were concerned that regulatory justification should be carried out prior to significant investment in construction of new nuclear power stations. This was because otherwise the economic case would ignore construction costs which would have already been spent. They said that this was the case for the Sellafield MOX plant when the Environment Agency had been considering justification.

Our response

1187 Responsibility for consideration of Regulatory Justification now falls to Government and not the Environment Agency. Government has considered Regulatory Justification for the reactor designs that have been undergoing GDA and following votes in Parliament, has issued the relevant statutory instruments for both the UK EPR and the AP1000 designs. Government's justification decisions were made prior to any significant construction expenditure in the UK on either design.

GDA's relationship to Planning and scope of GDA

1188 Some respondents asked if environmental impact assessment was linked to GDA assessment. Respondents also asked if reactor designers were considering wider environmental impacts than just waste.

Our response

1189 Environmental Impact Assessments are carried out by developers in support of their applications for planning consent. The impacts that are assessed relate to the specific development that is proposed and would be wider than those considered in GDA where we have focussed on matters that are regulated by the Environment Agency. In making their site-specific Environmental Impact Assessments, developers can / should draw on the information that has been presented in GDA where it is relevant to their proposals. As part of GDA we have sought and received information from the reactor designers on a number of environmental areas, for example combustion plant such as standby generators, rather than just waste.

Concerns about creation of waste and spent fuel

1190 Some respondents (GDA5, GDA56) considered that creation of radioactive waste can be avoided by not building new nuclear power stations and therefore they should not be built.

1191 Some respondents (GDA80, GDA166) asked about whether a robust approach was being taken with regard to uncertainties and risks of national policies and strategies.

1192 Some respondents (GDA82, GDA153) were concerned about the waste management strategy and proposals for new build wastes and spent fuel because of their reliance on the development of a Geological Disposal Facility (GDF) and interim storage of wastes until the facility became available.

1193 Some considered (GDA82, GDA149) that interim stores could actually become permanent disposal sites.

1194 Some (GDA114, GDA121, GDA154) were concerned about impacts on their local communities of long term interim waste storage and some that local communities were not well informed about proposals. Some respondents considered that it should not be assumed that the GDF would take new build wastes or that this would be acceptable to volunteer communities.

1195 Some (GDA82, GDA114) considered proposals were uncertain and that a credible scientific case for nuclear waste disposal has yet to be developed, that there were technical issues with current proposals, and took the view that no new build construction should begin or radioactive waste or spent fuel be created until this was the case.

1196 Some respondents cited in support the Flowers 1976 report view that "…*there should be no commitment to a large programme of nuclear fission power until it has been demonstrated beyond reasonable doubt that a method exists to ensure the safe containment of long-lived, highly radioactive waste for the indefinite future.*"

1197 Some respondents asked what would be the fallback if West Cumbria sites are not suitable for a GDF.

1198 Some respondents were concerned about the timescales for a GDF or asked about how this matter would be addressed in the planning system.

1199 Some respondents considered that the Environment Agency was deferring decisions on spent fuel disposability by the GDA issue it had identified in its GDA consultation documents.

1200 Some respondents (GDA51, GDA92) considered that not to reprocess spent fuel was expensive and wasteful and a failure by Government to implement its national policy for recycling of materials where possible.

1201 Other respondents considered that a change of spent fuel management proposals to include reprocessing would have massive financial and environmental consequences.

Our response

1202 Many of these points relate primarily to UK energy policy and the role of nuclear power. A consequence of nuclear generation would be the creation of radioactive waste. Government is responsible for energy policy and nuclear's role has been set out in Government White Papers and relevant National Policy Statements following extensive consultation. Government energy policy is outside the scope of our GDA consultation. Our and the other nuclear Regulators' role is to ensure that any radioactive wastes that are created, are processed, stored and disposed of safely, securely and with people and the environment properly protected. We provide advice to Government so as to help ensure that there is a robust approach to the treatment of uncertainties and risks in national policies and strategies.

1203 The need for a GDF to be developed for disposal of radioactive wastes is well established and will be required whether or not new nuclear power stations are built. Government's policy for securing this facility is set out in the Managing Radioactive Waste Safely (MRWS) White Paper and is based on the principle of volunteerism by local communities to host the facility. The Department of Energy and Climate Change is responsible for Government policy on radioactive wastes and it has given the responsibility for implementation of a GDF to the Nuclear Decommissioning Authority (NDA).

1204 The need for confidence in arrangements for the management and disposal of the radioactive wastes and spent fuel that would be created by new nuclear reactors was recognised in the 2008 Nuclear White Paper. It stated that "*before development consents for new nuclear power stations are granted, the Government will need to be satisfied that effective arrangements exist or will exist to manage and dispose of the waste they will produce.*" The Government has been carefully considered this issue and states in the Nuclear National Policy Statement that "*In reaching its view on the management and disposal of waste from new nuclear power stations the Government has in particular satisfied itself that:*

a) *geological disposal of higher activity radioactive waste, including waste from new nuclear power stations, is technically achievable;*

b) *a suitable site can be identified for the geological disposal of higher activity radioactive waste; and*

c) *safe, secure and environmentally acceptable interim storage arrangements will be available until a geological disposal facility can accept the waste.*

1205 The purpose of the Nuclear National Policy Statement is to provide guidance to the IPC about its planning decisions. The Energy National Policy Statements including that for nuclear energy, were ratified by DECC's Secretary of State in July 2011, following a vote in Parliament..

1206 The Environment Agency's role will be to assess proposals for the GDF and if it is acceptable to permit its use for disposals of radioactive wastes, including spent fuel, if it is acceptable. The introduction of the Environmental Permitting Regulations 2010 ensures that the Environment Agency will be involved in assessing the proposed GDF from an early stage in its development. We will also scrutinise and assess the disposability assessments that operators request from the NDA's Radioactive Waste Management Directorate so as to satisfy ourselves that the wastes, including spent fuel, are expected to be capable of being disposed of in the GDF once available.

1207 With regard to reprocessing of spent fuel, the 2008 Nuclear White Paper states that '….*the Government has concluded that any new nuclear power stations that might be built in the UK should proceed on the basis that spent fuel will not be reprocessed and that plans for, and financing of, waste management should proceed on this basis'.*

Concerns about interim stores

1208 Some respondents (GDA80) were concerned about proposals for the interim spent fuel stores that would be required at new build sites until disposal of the spent fuel in a GDF can be carried out. They noted that the Agency's GDA consultation documents referred to interim stores being designed to be maintained or replaced to last for at least 100 years, while the (*then)* draft Nuclear National Policy Statement assumed a requirement for up to 160 years to allow for adequate cooling of the spent fuel. They considered that designs should be consistent with the conservative case of 160 years. Some respondents considered that because of the 160 year or longer interim storage time for spent fuel at new build sites the principle of '*volunteerism*' by local communities put forward by CoRWM would not be met and that this would not be considered during the planning stage.

1209 Some respondents questioned DECC's waste and decommissioning proposals that propose that Government will take title to waste and spent fuel once decommissioning (of the reactor building) is completed and asked if this made more likely a national storage facility for waste and spent fuel, until a geological disposal facility became available.

1210 Some (GDA119) were concerned about the potential creation of a national facility.

1211 Some respondents (GDA102) were concerned about the security of spent fuel stores.

Our response

1212 The expectation that spent fuel might need to be stored for 160 years before it could be disposed of was based on a conservative assumption by NDA's Radioactive Waste Management Directorate that disposal canisters would be filled with the '*hottest*' fuel - that is fuel of the highest burnup and the same cooling time. This was the basis of the statements in the previous draft national Policy Statement. In its response to that consultation Government has given further consideration to this assumption and states that '…*the duration of storage of spent fuel after the end of power station operation could in principle be reduced to the order of 50 years through combining in disposal canisters fuel from the earlier years of operation with fuel from the later years of operation'*. On this basis the date at which spent fuel could be first disposed of, assuming 60 years operation beginning in 2018 and 50 years storage, is then close to the current 2130 date when it is projected access to the GDF will first become available for new build wastes following dealing with legacy wastes. The overall approach is consistent with our regulatory expectation that disposals in a GDF should be optimised so as to make best use of its capacity and in our view a proposal for an interim store is very different to a proposal for a GDF to which CoRWM's volunteerism' approach applies. Whatever the duration of interim storage the Regulators will collectively require operators to store waste safely and securely and with the environment properly protected. With regard to security at civil nuclear sites, this is also regulated by the Office of Civil Nuclear Security.

1213 The Government has set out its base case assumption that spent fuel will be stored on the site of the new nuclear power station until it is disposed of in a GDF. This is a prudent assumption in the absence of any firm proposals for alternative arrangements, such as regional or central stores, where ILW and spent fuel could be stored prior to disposal. However Government has said that it does not wish to preclude alternative arrangements, for example a central storage facility, if a site can be identified and the necessary regulatory and planning permissions obtained. This is reflected in the designated Nuclear National Policy Statement.

Other issues

1214 Some respondents (for example GDA153) asked about whether Regulators are confident that they can deal with long term issues – climate change for example.

1215 Some respondents noted that possible changes in the pipeline such as with regard to radiation dose limits are not addressed.

1216 A respondent (GDA159) expressed concern about EDF's management practices in France and the UK with regard to containment of radioactive materials, contamination of workers at Tricastin, France and Hinkley Point B and their nuclear safety record more generally. The respondent asked that, if a licence was granted for a new nuclear power station, then a wide scale programme for pre-distribution of potassium iodate tablets should be implemented.

1217 A respondent (GDA82) noted that the potential implications for higher dose rates from transport flasks along transport routes had not been examined.

1218 A respondent (GDA159) expressed concern about a decision of the NDA to incinerate reactor core graphite.

Our response

1219 The nuclear Regulators, including the Office for Nuclear Regulation and the Environment Agency play an important role in ensuring the safety, security and protection of people and the environment in relation to the design, construction, operation and decommissioning of nuclear power stations, the transport of nuclear material and the disposal of radioactive and other wastes that arise. We provide advice to Government, potential operators and others on relevant matters including on the potential implications climate change. We consider and, where relevant, take account of developments and learning from experience worldwide and expect the operators that we regulate to do the same. This would include, for example, any statutory changes to dose limits.

1220 In GDA we have considered the management systems that have been implemented by the requesting parties (EDF and AREVA, and Westinghouse) that are relevant to their development, specification and control of their generic reactor designs. The nuclear Regulators would similarly consider the management systems that potential operators of new nuclear power stations propose to implement when they bring forward site-specific proposals and applications for relevant permits and licences. The proposed systems would have to be acceptable to the Regulators having regard to the then life-cycle stage of the power station, for example: design, construction, commissioning, operation. Proposed site-specific emergency arrangements, including those relating to distribution of potassium iodate tablets, would be set out at the appropriate stage for the consideration of relevant bodies including Regulators, local authorities and health authorities.

1221 Transport of radioactive materials and wastes is also regulated by the Office for Nuclear Regulation. Proposals for the transport of radioactive wastes from specific sites, including any radiation doses would have to be considered and acceptable to them.

1222 Pressurised water reactors such as the UK EPR or the AP1000 do not have graphite cores unlike the existing Magnox and AGR reactors built in the UK and therefore consideration of this waste disposal route is not relevant to current GDA considerations. However, in any case, we would only permit a proposed method of waste disposal if we considered that people and the environment would be properly protected.

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