Generic design assessment

AP1000® nuclear power plant design by Westinghouse Electric Company LLC

Decision document

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Foreword

I'm pleased to introduce our decision document on Westinghouse's AP1000® 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 UK EPR™ design, the other reactor design in the GDA programme which was submitted by EDF and AREVA.

We have decided to issue an *interim* Statement of Design Acceptability for the AP1000 design 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 AP1000 design.

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 AP1000 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 Westinghouse has 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 AP1000 design.

There are some areas where work would be required by the *operators* if they decide to pursue construction of an AP1000 reactor. 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 us 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 (the reactor designers) 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 Westinghouse Electric Company LLC ('Westinghouse') submitted its AP1000 nuclear power plant design for generic design assessment in August 2007. Westinghouse published its submission on its website (www.ukap1000application.com) 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 AP1000 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 AP1000 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 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. In effect, our assessment was extended 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 Westinghouse has provided a response 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 AP1000 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, commissioning, or early operation.

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 Westinghouse's submission for the AP1000 nuclear power plant design and our conclusion, following consultation, is that we could issue an interim Statement of Design Acceptability (iSoDA) for the AP1000 design. 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 AP1000 design. Our decision is subject to two GDA Issues, both joint with ONR. Westinghouse has 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) Westinghouse to submit a safety case to support the GDA Design Reference and then to control, maintain and develop the GDA submission documentation, and deliver final consolidated versions of these as the key references to any DAC/SoDA the Regulators may issue at the end of GDA. 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 12 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**
AP1000-AF01	The future operator shall provide at the detailed design stage, an updated decommissioning strategy and decommissioning plan.

Reference	Assessment finding
AP1000-AF02	Future Operators shall, at the detailed design phase, provide a Best Available Techniques (BAT) assessment to demonstrate whether boron recycling represents BAT for their location.
AP1000-AF03	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.
AP1000-AF04	Future Operators shall, before the construction phase, provide a BAT assessment to demonstrate that the design and capacity of secondary containment proposed for the monitor tanks is adequate for their location
AP1000-AF05	Future operators shall, at the detailed design phase, provide an assessment to demonstrate that techniques to minimise the discharge of all aqueous radioactive wastes are BAT for their location. In particular, the omission of an evaporator will need to be justified.
AP1000-AF06	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.
AP1000-AF07	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 Westinghouse's plan for disposability of ILW.
AP1000-AF08	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 LLW and ILW are BAT.
AP1000-AF09	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.
AP1000-AF10	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, if the Westinghouse reference dry spent fuel storage option is not chosen. The future operator shall provide an assessment to show that the techniques proposed are BAT.

Reference	Assessment finding
AP1000-AF11	The future operator shall provide confidence, before the commissioning phase, 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 Westinghouse's plan for disposability of spent fuel.
AP1000-AF12	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 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.

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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 AP1000®, by Westinghouse Electric Company LLC (Westinghouse) (the 'requesting party').

18 The Office for Nuclear Regulation[2] (ONR) is also assessing the AP1000 design 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 AP1000 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 Westinghouse 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 AP1000 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, at the strategic level, that 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 to be established 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, Westinghouse's AP1000 and EDF and AREVA's UK EPR, 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 template permit 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 AP1000 design in GDA.

2.5.1 Initiation and preliminary assessment

38 Our process for the first stage of GDA for the AP1000 design is described in our report on our preliminary assessment (Environment Agency, 2008a). In summary:

a) We set up an agreement with Westinghouse Electric Company LLC to carry out GDA of the AP1000 design, which came into effect in July 2007.

b) The Joint Programme Office (JPO) received Westinghouse'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 Westinghouse in February 2008 setting out the further information that we needed.

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

g) Westinghouse completely revised its submission during 2008 and provided an environment report (ER) with supporting documents. It reviewed and updated the ER in March-April 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 Westinghouse 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 (which was subsequently closed) and in response to 43 Technical Queries and fourteen Regulatory Observations that we raised during our detailed assessment. Westinghouse also arranged a number of site visits to support the claims it was 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 the United States Nuclear Regulatory Commission (NRC) and the Swedish Radiation Safety Authority (SSM).

42 One area of our assessment is the design, layout and operation of the proposed AP1000 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 Westinghouse 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 Westinghouse GDA submission identifies a number of options for operating the AP1000 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 or decision.

46 The visits were successful in establishing that different operational approaches can be successfully implemented. The relevant examples are referenced in our final 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 Final 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 final 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 Westinghouse 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 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 design, 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.

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

64 To help the consultation process, we also included in the consultation document a draft interim statement of design acceptability for the AP1000 design based on our initial (that is, before consultation) view.

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 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' 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. Westinghouse updated its 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 the ONR's Step 4 reports). Therefore, we have not considered any comments received via 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 Final Assessment Reports where we have received additional information that has informed our decision on the acceptability of the AP1000 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 (e.g. 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 (e.g. GDA76 is for the Health & Safety Executive (now the Office for Nuclear Regulation (ONR))), 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 (GDA120) 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 (GDA150) 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, the criteria from which are included at Annex 6 of this Decision Document.

c) Greenpeace (GDA152) 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 (GDA152) 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 (GDA152) 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 (GDA150) and Greenpeace (GDA152) also raise a number of other concerns regarding our findings, and these are addressed at the appropriate point in Chapters 5 – 14 and Annex 8.

88 The 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 AP1000 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 AP1000 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 an interim SoDA, we are confident that the AP1000 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 require both the ONR Design Acceptance Confirmation (DAC) and our SoDA, when issued, 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 AP1000 with a number of GDA Issues requiring resolution by Westinghouse. As resolution of these GDA Issues may impact on matters relevant to our area of responsibility, and will lead to a revised Design Reference, we will only grant a full SoDA when the

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4 A Consent is required before the nuclear site licensee can carry out certain activities identified in the licence or other activities which HSE has the power to specify. For example, a Consent from HSE 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 HSE 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

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, Westinghouse has 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 Westinghouse 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 Westinghouse 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 Plan 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 'other issues'.

For clarity in this Decision Document the term assessment findings 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 AP1000 at the proposed site will be as low as reasonably practicable (ALARP) and below relevant dose constraint and dose limits (see Chapter 13).

b) 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 (see Chapter 14).

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

2.6 Regulatory basis for GDA

111 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]

112 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).

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).

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[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.

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.

113 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.

114 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.

115 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

116 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.

117 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.

118 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.

119 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.

120 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.

121 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.

122 To ensure that the lessons learnt from the Fukushima accident are considered within GDA, we and ONR raised a further GDA Issue on Westinghouse to address any lessons to be learnt for the generic AP1000 reactor design. This requests Westinghouse to demonstrate how they will take account of the lessons learnt from the unprecedented events at Fukushima, both from those arising out of Westinghouse'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.

123 Westinghouse has provided a Resolution Plan to describe how they will address the recommendations. We consider that this Resolution Plan is credible. If Westinghouse implements execution of its resolution plans, 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.

124 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 AP1000® design

125 Westinghouse submitted the AP1000® design for GDA. The submission includes the use of Westinghouse 17RFA fuel assemblies. This section provides a brief outline of the AP1000 design and how it is proposed that waste will be created, processed and disposed of.

3.1 Outline of the design

126 The AP1000 design is a single, pressurised water reactor (PWR) capable of generating nominally 1117 megawatts (MW) of electricity, with a claimed 60 year design life. AP stands for 'advanced passive', as it is claimed that the AP1000 uses passive safety systems such as natural circulation and gravity. Westinghouse claims that the AP1000 safety systems are designed to mitigate the consequences of plant failures, ensuring the reactor shuts down, decay heat is removed, and releases of radioactivity are prevented. In the reactor core, the uranium oxide fuel (enriched up to 4.95 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 two steam generators where heat is transferred from this primary coolant circuit to a secondary circuit, producing steam. This steam then drives a turbine-generator to produce electricity, is condensed, and the condensate returned to the steam generators.

127 The AP1000 reactor is a plant design incorporating six buildings (see Figure 3.1 below from the ER). The design comprises the nuclear island (containment/shield building, and auxiliary building), annex, diesel generator, turbine generator, and radwaste buildings. The main ancillary facilities include a spent-fuel storage pool, water treatment systems for maintaining the chemistry of the primary and secondary water circuits, two diesel generators for providing power in the event of loss of grid supplies, and waste treatment and storage facilities. For the purpose of generic design assessment, turbine condenser cooling water is provided by a once-through system using seawater.

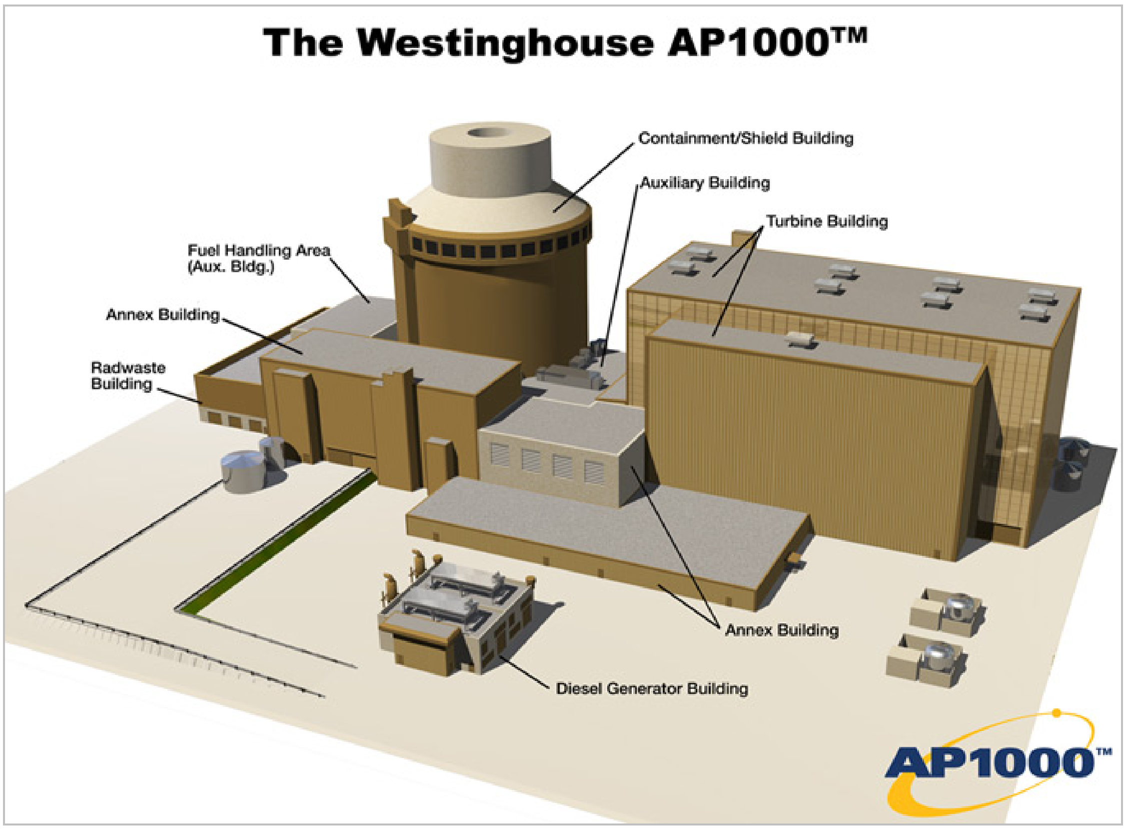


Figure 3.1: AP1000 Schematic (Environment Report Figure 2.3-1)

128 The AP1000 has evolved from earlier Westinghouse Electric Company LLC PWR designs, the most recent of which is the AP600® reactor. The Sizewell B reactor is the only operating PWR in the UK and is a Westinghouse design. The current AP1000 design is undergoing reviewer certification by the nuclear regulator in the USA, the Nuclear Regulatory Commission (NRC), to address new regulatory requirements (on the shield building) and design finalisation changes. The AP600 achieved Design Certification in 1999 from US NRC but was never constructed. AP1000 maintains the AP600 configuration and the US licensing basis by limiting the design changes. There are currently a number of applications for combined construction and operating licences in the US for AP1000. These have to be assessed, and design approval given by US NRC before any construction is permitted. Four AP1000 plants are already under construction in China – two at Sanmen and two at Haiyang. Westinghouse and China are currently discussing plans for additional AP1000 plants to be sited inland of China's coastal areas. Additionally, Westinghouse and the AP1000 have currently been identified as the supplier and technology of choice for 14 plants that have been announced in the United States, including six for which engineering, procurement and construction contracts have been signed. The AP1000 is certified by the U.S. Nuclear Regulatory Commission, and is the only Generation III+ reactor to receive such certification. The European Utility Requirements (EUR) organisation also certified that the AP1000 is compliant with European Utility Requirements, confirming that the AP1000 can be successfully used in Europe.

3.2 Sources, processing and disposal of radioactive waste

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 are subsequently transferred to waste items.

130 Discharges of radioactive waste dissolved or carried in water (aqueous discharges) are produced mainly from effluents associated with systems for collecting and treating the primary coolant water. Other sources of effluent include the fuel pool purification system, washings from plant decontamination, and drainage (detergent waste) from change-rooms. The detergent waste activity is monitored, and if it is sufficiently low, then it is discharged without processing. Effluent treatment facilities include accumulation, hold up and monitoring tanks; filters; and demineraliser ion exchange resin beds. Facilities to sample and monitor aqueous wastes before they are released are provided. Final discharge is to the sea combined with the cooling water.

131 The main source of gaseous radioactive discharges is the gaseous component arising within the coolant circuit which is collected by the gaseous radwaste system (GRWS) and held for decay storage in the activated carbon bed delay system. The system includes a gas cooler, a moisture separator, an activated carbon-filled guard bed, and two activated carbon-filled delay beds. The gaseous waste from the delay bed passes through a radiation monitor and discharges to the ventilation exhaust duct. Gaseous activity will also be present in the main process buildings, which are serviced by the heating, ventilation and air-conditioning (HVAC) systems. Discharges from these systems to air are through a stack located on the top of the nuclear island. There is provision for monitoring these discharges intermittently after filtration through high efficiency particulate air (HEPA) filters and, where appropriate, charcoal adsorption. There is also the possibility of tritium in the secondary circuit from minor leaks from the primary circuit. This is collected in the condenser air removal system. There are provisions for sampling and monitoring gaseous wastes at various points in the gaseous radwaste system.

132 Other radioactive waste created by the AP1000 includes spent ion exchange resins, and deep bed filtration media, spent filter cartridges, worn-out plant components and parts, contaminated protective clothing and tools, rags and tissues, and waste oil. This waste is collected by the solid waste management system where decay storage or basic conditioning is carried out to enable off-site disposal.

133 Westinghouse Electric Company LLC does not expect that any novel solid waste streams will be generated by the AP1000. Most solid low level radioactive waste (LLW) will meet the appropriate criteria for disposal at the UK National LLW Repository (LLWR) near Drigg in Cumbria.

134 All radioactive plant components are likely to become waste when the plant is decommissioned. The strategy for disposing of decommissioning waste will be provided in further information, as noted elsewhere in this document.

135 Spent fuel will be stored initially under water in the spent-fuel storage pool. The options for longer term management are described later in this document.

3.3 Non-radioactive waste

136 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 and other non-active cooling systems, which is discharged to sea;

c) waste lubricating oils;

d) screenings from sea inlet filters;

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

137 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

138 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 (BAT) 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).

139 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 Westinghouse 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.

140 Our conclusions:

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

i) Westinghouse 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 or commissioning phase of a plant (for example, demonstration that as-built plant realises the intended design);

ii) matters that depend on site-specific characteristics.

141 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.

142 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 .

143 As part of our agreed GDA process with the RPs, 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.

144 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 Westinghouse and it committed to providing further information. Westinghouse provided a completely revised submission, its 'environment report' (ER) with supporting documents. It has published the ER and other documents on its website (https://www.ukap1000application.com).

145 During our assessment of the ER, we had some concerns and needed some additional information. We raised fourteen ROs and 43 TQs on Westinghouse, some of which were joint with ONR. In addition we collaborated with ONR in some of the ROs and TQs they raised. Additional ROs and, or, further RO actions were raised jointly with ONR following our consultation on waste and spent fuel, and Quality Assurance An additional TQ was raised on multi-reactor sites for AP1000. 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 ER and some additional supporting documents, as now available on the website noted above. We published our preliminary conclusions of our detailed assessment in June 2010 in our consultation document.

146 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 the 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) Environment report (ER);

b) Pre-construction safety report (PCSR);

c) AP1000 integrated waste strategy document (IWS);

d) AP1000 nuclear power plant BAT assessment (AP1000 BAT);

e) AP1000 European design control document (DCD).

f) Design reference point (DRP).

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

148 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.*'

149 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 AP1000. 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 e.g. Germany only requires the measuring and reporting of carbon-14 in CO_2 form.

150 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.

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

5 Management systems

5.1 Conclusions

152 Our conclusions remain unchanged since our consultation but are subject to a GDA issue (see 5.2).

153 **We conclude that Westinghouse has 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.**

154 **We conclude that Westinghouse has adequately specified:**

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

b) **How it expects to transfer knowledge and to provide continuing support to any operating company.**

5.2 GDA issue

155 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 Westinghouse. This reflects that Westinghouse 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 (DAC) / statement of design acceptability (SoDA) from the Regulators.

156 The GDA issue is:

a) Westinghouse to submit a safety case to support the GDA Design Reference and then to control, maintain and develop the GDA submission documentation, including the Safety, Security and Environment Report (SSER), the Master Submission List (MSL) 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. (GI-AP1000-CC-02).

5.3 Background

5.3.1 Joint Regulators' Inspection November 2007

157 We examined Westinghouse's management system in detail during our preliminary assessment in 2007-8, and concluded that it was suitable for controlling the content and accuracy of the information Westinghouse has 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 joint Regulators' inspection in 2007 for Westinghouse to consider.

158 Westinghouse's progress in relation to implementing the recommendations is summarised below:

a) Recommendation 1: a formal project quality assurance plan has been produced for the UK project. At the time of writing our consultation document, this document was being revised following review comments by the joint Regulators. Westinghouse have since produced a revised quality assurance plan for the project.

b) Recommendation 2: Westinghouse produced a formal history documenting the development of the AP1000 design.

c) Recommendation 3: Westinghouse produced a training module for staff working on the UK project and implemented training for the staff.

d) Recommendation 4: Westinghouse created and implemented a formal learning organisation to capture and communicate learning from operating experience.

e) Recommendation 5: Westinghouse provided further information on waste strategy and decommissioning in its submission documents. This matter is addressed elsewhere in our decision document.

159 During the detailed assessment stage, we kept Westinghouse's management arrangements under review. A significant part of our assessment activity involved inspection to review the application of Westinghouse's arrangements to the UK GDA project, and to identify evidence that it has effectively implemented arrangements.

5.3.2 Joint Regulators Inspection March-April 2009

160 A joint Regulators' inspection of Westinghouse's management arrangements was arranged for March - April 2009 to follow up progress on implementing the recommendations from our initial inspection in November 2007. The inspection was also carried out to assess whether Westinghouse was applying its quality management systems to the UK GDA project, namely to establish that Westinghouse has implemented and continues to review arrangements that control its GDA related activities. The inspection focused on and re-examined the arrangements for controlling modifications to the AP1000 design; configuration control for GDA submission documents and arrangements for transmitting submission documents to the regulators; internal, external and third party certification audits; learning from experience, and procurement arrangements.

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

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

163 The joint Regulators' conclusion from the 2009 inspection was that:

a) Westinghouse continues to operate a well-developed set of quality arrangements that include sub-tier procedures that are periodically reviewed and audited.

b) A GDA specific quality plan was developed, supported by a number of related GDA procedures, that are designed to formalise the interface between the Joint Programme Office (JPO) and Westinghouse.

c) The inspection team considers that the joint regulators' confidence in the arrangements for the remainder of GDA could be improved by applying all the elements of the Westinghouse quality programme to the UK GDA project.

d) It is acknowledged that Westinghouse has experienced and knowledgeable staff and a commitment to retain adequate technical resources. Westinghouse has established a number of targeted initiatives that have addressed organisational learning and continuous improvement. However, the full benefit of these initiatives has not been realised for the UK GDA project as the level of application to the project appears to be minimal. This leads to some doubt regarding the effective application of Westinghouse processes to the UK GDA project.

5.3.3 Regulatory Observations

164 We had previously issued a Regulatory Observation (RO), RO-AP1000-17 UK GDA Quality Assurance Processes, concerning Westinghouse applying quality management arrangements specifically to GDA submission documents. Following the 2009 inspection, the Regulators issued comments on Westinghouse's quality plan and procedures for the UK GDA project. These were issued in the form of two additional RO actions to RO-AP1000-17 in May 2009 requiring Westinghouse to update, revise and implement the plan and procedures for UK GDA.

165 In addition, following the 2009 inspection, we issued a new RO, RO-AP1000-35, requiring Westinghouse to demonstrate that it was applying the full rigour of its Quality Management System (QMS) to the UK GDA project.

166 We issued a further RO, RO-AP1000-33, in regard to quality issues for the environment report (ER) submission.

167 Westinghouse discussed details of its progress in implementing the 2009 inspection recommendations at a progress update meeting with the joint regulators in September 2009. Further meetings were held in 2010 between the Regulators and Westinghouse to discuss progress on QA matters, and Westinghouse provided a formal response on all QA matters including ROs RO-AP1000-17, RO-AP1000-33 and RO-AP1000-35, WEC response to Regulatory Expectations for UK AP1000 GDA for MSQA by letter of 11 March 2010. The response contained a series of documents and attachments as supporting evidence to actions taken on the inspection recommendations. These were given detailed consideration as part of our assessment. Please refer to our final assessment report on management systems (listed in Annex 3).

168 Following the 11 March letter from Westinghouse, a commitment letter outlining the work programme for Westinghouse to close out any remaining QMS issues during GDA was provided by Westinghouse on 14 April 2010. This included a programme detailing its quality assurance improvement plan, including commitments to applying the full suite of its QMS procedures to the UK GDA project. This is discussed further in our final assessment report.

169 In response to RO-AP1000-33, Westinghouse produced a revised environment report in December 2009 to address the quality issues in the previous report. Following a review of this report by the regulators, the RO was closed in March 2010.

5.4 Ongoing work since our consultation proposals were published

170 In response to RO-AP1000-35, Westinghouse provided information on 31 August 2009 concerning the application of it's quality procedures to the UK GDA project. In addition, following an internal audit of the AP1000 reactor international projects and two self assessments of the UK GDA project, Westinghouse sent an update of their response to RO-AP1000-35 to the Regulators in October 2009. This response included an attachment specifically to advise on how the Westinghouse QMS applies to UK GDA and also provided details of an audit of the UK GDA Project Quality Plan for compliance with the Westinghouse QMS.

5.4.1 Joint Regulators Inspection July 2010

171 A readiness review was conducted in May 2010 at the UK GDA project office of Westinghouse by its US head office-based professional QA staff. Following this, the joint Regulators carried out an inspection in July 2010 at the Westinghouse UK GDA project office to assess Westinghouse's arrangements for quality assurance and the implementation of their quality management system to deliver GDA. The inspection found the Quality Plan and the procedures for the UK GDA project had been revised. There was evidence that staff had been trained and were aware of their role and responsibilities in GDA.

172 Our findings were supported by a successful third party audit conducted by Lloyds Register (LRQA) in June/July 2010, which tested the adequacy of Westinghouse's QMS arrangements in respect to the GDA project. No significant issues or non-conformances were raised.

173 On the basis of our July 2010 Inspection findings, and evidence provided by Westinghouse in implementing their QA improvement plan, the Joint Regulators agreed to close out RO-AP1000-17 and RO-AP1000-35. The Regulators wrote to Westinghouse in July 2010 to close out the ROs, and provide further comment on the Project Quality Plan and Procedures; these comments were not of significant severity to prevent the close out of the ROs.

174 Thus our concerns on QA matters as detailed in our consultation are considered closed.

5.5 Consultation responses

175 At the time our Consultation began in June 2010, we concluded that progress had been made by Westinghouse and we had seen evidence that Westinghouse's QMS had been applied to the UK GDA project. However, there remained outstanding QA matters for Westinghouse to resolve and close out during GDA in agreement with the Regulators. Two ROs remained open, RO-AP1000-17 and RO-AP1000-35. These required the UK GDA Project Quality Plan and Procedures to be revised, and for Westinghouse to demonstrate the application of the full rigour of its QMS to the UK GDA project.

176 One respondent (GDA124) 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*?'.

177 Information is provided in the project quality plan (Revision 3, April 2010) to indicate that Westinghouse management systems applied to the AP1000 reactor project

comply with international standards, for example ISO 9001 Quality Management Systems. There are external audits carried out, including assessments by recognised accreditation bodies. The Westinghouse Quality Management System is certified to ISO 9001:2008 by LRQA. This information has been discussed with the joint Regulators during the GDA inspections, and the inspection reports are available on the joint website.

178 Ingleby Barwick Town Council (GDA 39) commented ' *I am doubtful as to whether the same health and safety and environmental concerns will be addressed in the USA and China as it is in Great Britain. We must therefore err on the side of caution and ensure that all aspects of their management systems are ideal for Great Britain*'.

179 Westinghouse management systems have been assessed in line with UK regulatory requirements by ONR and Environment Agency who share regulatory responsibility for QA issues. The joint Regulators assessments and inspections of Westinghouse's management systems have been underway since late 2007. The Regulators consider there is sufficient evidence that Westinghouse have adequate management systems in place during GDA. Westinghouse established a UK project office with management systems in place in support of the UK GDA project, including UK specific procedures, and work instructions, as detailed later.

180 The Institution of Mechanical Engineers (GDA 146) 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'*.

181 Westinghouse applied for GDA against a single AP1000 reactor. However should twin or triple reactors be proposed at the site-specific stage, then the management system proposed as part of the operator's arrangements would be assessed to determine if it is appropriate.

182 Some consultation responses (GDA14, GDA26, GDA71) supported our preliminary conclusions on management systems. '*I agree with the preliminary conclusions*' (GDA14). '*The conclusions on Westinghouse management and information exchange systems appear robust and relevant* ' (GDA71).

183 A respondent (GDA59) acknowledged that some QA matters remained outstanding for Westinghouse in regard to our preliminary conclusions on management systems. Another respondent (GDA71) commented ' *The noted QMS issue should be readily resolvable. Quality Assurance is well understood and applied throughout the nuclear industry worldwide*'.

184 A respondent (GDA146) queried the outstanding issues on QA, noting they did not have the detail of the perceived shortfalls but that it was difficult to judge whether the issue was warranted. They supported the need for a rigorous application of management systems during design and construction, but noted that '*pedantic application of lower tier documentation at this stage could be seen as bureaucratic and costly and cause delays*'.

185 Westinghouse (GDA110) responded to our consultation and noted their commitment to resolve any outstanding issues in the GDA process.

186 Following the publication of our consultation, further work has resulted in the Regulators being satisfied that the outstanding QA matters have been resolved, and both ROs, RO-AP1000-17 and RP-AP1000-35 have been closed.

187 A number of consultation responses were received in regard to management systems. 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 2010 GDA

Stakeholder Seminar and are considered in this document.
http://www.hse.gov.uk/newreactors/seminar-060710.pdf

188 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.

5.6 Design Reference Point

189 The AP1000 design reference for UK GDA is described in 'Design Reference Point' UKP-GW-GL-060. The Design Reference Point (DRP) must describe the generic reactor design for which Westinghouse is seeking a UK design acceptance confirmation (DAC), and statement of design acceptability (SoDA) from the Regulators.

190 At the time of our public consultation, our findings and preliminary conclusions were based on the DRP and design freeze of 23 December 2009. However, Westinghouse updated their DRP in December 2010, changing the design freeze date to 16 Sept 2010.

191 For the regulators to be able to complete a meaningful GDA, Westinghouse needs to ensure that the DRP, the safety, security and environment reports (SSER) and supporting documentation as captured in the master submission list (MSL) are valid, consistent and applicable to the UK. Following the change of DRP, the Regulators issued a RO RO-AP1000-103 on 4 November 2010 to ensure that Westinghouse aligned the GDA submission documentation and DRP. As part of this RO, the Environment Agency requested details of any design changes that may impact the environment. Westinghouse provided details of their design change control process for GDA to the regulators. Once a design change has been decided, the proposal for the change is submitted via Westinghouse's Design Change Proposal (DCP) process.

192 ONR has conducted two inspections of Westinghouse's QA arrangements, in August 2010 and November 2010, followed by an inspection by the joint Regulators in December 2010. These inspections confirmed that there were still several issues related to the content and definition of the design reference and design change control. The current DRP (revision 5) has been received and the RO was closed in May 2011. However, to date, a number of design changes have been included in the DRP without full consideration of the impact to the safety submission and without consent of the Regulators. The GDA issue GI-AP1000-CC-02 has been raised to resolve this matter (see Schedule 2 to Annex 1).

5.6.1 Management of design changes during GDA and changes to the Design Reference Point (DRP)

193 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?*' As noted above, Westinghouse is required to submit a 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 can only be made by submission to the joint Regulators' Assessment Review Group (ARG).

194 Cumbria County Council (GDA166) commented on our consultation in regard to the UK EPR design querying how the joint Regulators plan to manage changes to the

design in GDA, specifically design improvements arising from construction of new reactors in France and Finland. This comment is considered applicable for the AP1000 design since AP1000 reactors are currently under construction in China.

195 There is a process for changes in design, resulting from design improvements or regulatory requirements, to be taken into account during GDA. Westinghouse is 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. The proposed changes are considered by the ARG. The Regulators then provide formal agreement (or not) in writing to Westinghouse in regard to inclusion of the change proposal in GDA.

196 Westinghouse wrote to the Regulators in January 2011 and then in February 2011, with an update of design changes, providing further information on DCPs that Westinghouse wish to be considered for inclusion in GDA. These include for example design improvements in filtration in regard to meeting the regulators' requirements for nuclear ventilation.

5.6.2 GDA Issue

197 Our GDA conclusions are subject to a joint GDA Issue with ONR which reflects that Westinghouse will need to continue to control changes to GDA submission documents, resulting from the management of design changes, until the issue of the DAC/SoDA from the Regulators.

198 The GDA issue has three actions:

a) **Westinghouse to submit a safety case to support the GDA Design Reference and then to control, maintain and develop the GDA submission documentation, including the SSER, the MSL 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.**

b) **Westinghouse is required to make and implement arrangements to control, maintain and develop the GDA safety submission documentation. This must include the SSER, MSL and design reference documents. As part of this action, Westinghouse shall deliver final consolidated versions of these documents as the key references to any DAC/SoDA we may issue at the end of GDA. This should involve the incorporation of all relevant amendments into the impacted documentation associated with design changes, including the Design Reference UKP-GW-GL-060, MSL and the PCSR. This should include any other additionally agreed design changes associated with other GDA Issue Resolution Plans. Westinghouse arrangements shall ensure no modification to the design or safety case, which may affect safety, is made except in accordance with agreed arrangements and will provide for the classification of modifications according to their safety significance.**

c) **Westinghouse to implement the outstanding GDA agreed design changes, by incorporating the change details into all impacted DR, the MSL documentation including the PCSR, ER. The scope of this work should include those design changes already agreed for inclusion in GDA Step 4 but not incorporated and any additional design changes arising as part of other GDA Issue resolution plans or arising during the GDA close out stage.**

199 **During the site**-specific phase, further design changes may be proposed for the AP1000 design as a result of learning from experience on AP1000 reactor construction projects. We would expect the future operator to have appropriate

arrangements in place to control and manage such design changes at the site-specific stage.

5.6.3 Conclusions - Design Change in GDA and DRP

200 In conclusion, we are satisfied that Westinghouse's management arrangements for the AP1000 design in GDA are adequate, on the basis of assessment work documented in our consultation and the ongoing work reviewed since then. In particular, the further inspections carried out by the Regulators, and the further work carried out by Westinghouse to implement their QA improvement plan.

201 **We conclude that Westinghouse has 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.**

202 Matters still to be resolved are identified in this report as a GDA Issue GI-AP1000-CC-02 (see Schedule 2 of Annex 1) and this will require an associated Resolution Plan to be proposed by Westinghouse. This Issue will require resolution before the Environment Agency would grant a permit, and ONR would agree to the commencement of nuclear safety related construction of an AP1000 reactor in the UK.

5.7 Expectations for the operator's management system

203 Before a site-specific application for an AP1000 reactor 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. Implications of the design for the potential operator's management system, and how information and support will be provided to the operator needs to be addressed by Westinghouse in it's GDA submissions.

204 Ingleby Barwick Town Council (GDA38) responded to our consultation for UK EPR 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*'. This comment is considered applicable to the AP1000 design.

205 Springfields Site Stakeholder Group (GDA97) 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*'. An individual respondent (GDA14) made similar comments.

206 An individual respondent (GDA85) raised a concern about the financial failure of Westinghouse. The potential for financial failure of Westinghouse is not considered to be within the scope of GDA. However, we do consider the development of the intelligent operator for the AP1000 design in regard to the transfer of knowledge about the design between Westinghouse and the future operator. We would expect that the future operator would be capable to act as intelligent operator for the AP1000 design.

207 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 Westinghouse against our expectations for the operators management systems.

208 Reference 1.1 of Table 1 of our GDA guidance document, the process and information document (Environment Agency, 2007) requires Westinghouse to set out its expectations of the operator's management system to cover the reactor's operations throughout its lifecycle. With ONR, we asked Westinghouse to provide further information in TQ-AP1000-330, specifically, to address in its GDA submission, the implications of the AP1000 design for the potential operator's management system. In particular, we want to know how Westinghouse intends to transfer the necessary information about the AP1000 design, and the arrangements that would be in place to provide ongoing support to the potential operator. Westinghouse developed its proposals in liaison with its utility partners, and we welcome their involvement.

209 Westinghouse's submission addresses these matters in:

a) AP1000 Pre-Construction Safety Report PCSR

b) Plant Life Cycle Safety Report

c) UK AP1000 Environment Report Section 1.4 Management System

d) Plant Operations, Surveillance, and Maintenance Procedures

210 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 Westinghouse, as the design organisation, to the operator so that it can act as an effective design authority.

211 Westinghouse submissions included '*Westinghouse will ensure that design and operational knowledge is transferred to the licensee of the operating organisation in order to permit it to perform as an intelligent customer. This knowledge transfer include the provision of design information and comprehensive training and education programmes such that the licensee can establish a credible design authority*'. Westinghouse recognises the importance of transferring the design authority role to the operating organisation. It also recognises the importance of training and development during the design phase for licensee personnel in regard to the AP1000 design.

212 Westinghouse continued to develop the Plant Life Cycle Safety Report (LCSR), and submitted a new revision in March 2011. The report describes the arrangements for the overall AP1000 GDA project and the requirements and provisions for different phases from design through to decommissioning. It includes a safety and quality philosophy, and incorporates issues such as knowledge transfer in 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). It also includes details of organisational arrangements for moving to an operational regime with information on procedures, training and records.

213 Westinghouse provided a copy of the plant operations, surveillance and maintenance procedures for the AP1000 reactor. This document includes listings of emergency operating procedures, normal operating procedures and abnormal operating procedures that will be required to operate the AP1000 reactor.

214 Westinghouse has agreed with their potential utility customers that the submissions it makes to the regulators during GDA will describe the management of the process to cover vendor expectations of the operator's management arrangements, and interactions between the vendor and operator, before any site licence application is made.

215 Westinghouse has an established design procedure that includes a thorough design review process. The process is described in the LCSR. Robust design change procedures are in place to assess and control the effect of design changes on safety and these were discussed with the joint Regulators during the 2007 and 2009 inspections.

216 Westinghouse sets out its expectations for a potential operator's management system where safety and environment may be impacted. It gives an overview of those aspects of the management arrangements where transfer of information, education or continued support will be necessary to ensure safe and environmentally sound operations. The arrangements for transferring knowledge and retaining competence are set out. Westinghouse states that knowledge transfer will be systematically carried out starting from the arrangements in place during GDA. This includes involving the utility partners who play an active role in review and input to the environment and safety submissions. The utility partners have formed the AP1000 GDA Submission Steering Committee (AGSSC) to input, review and comment on GDA submissions for the AP1000 design. In this respect, the process of knowledge transfer in regard to the design is occurring. Further information on knowledge and information transfer to the operator in regard to the AP1000 design is provided in the March 2011 update to the LCSR.

217 Horizon (GDA128) confirmed that transfer of knowledge to it as a potential future operator for the AP1000 reactor was already underway as one of the utility partners in GDA.

218 The Institute of Mechanical Engineers (GDA146) noted its support for the formation of the AGSSC allowing the process of knowledge transfer about the design to occur to prospective operators.

219 There will be a number of design changes which will remain unincorporated at the end of GDA and will need to be transferred into the site-specific and licensing phase. We will require that future operators demonstrate that adequate management arrangements are in place for identifying, transferring, tracking and implementing the incomplete approved design changes for the AP1000 reactor.

220 One of the 'other issues' included in Chapter 8 of our consultation document was that detailed arrangements for the handover between Westinghouse and future operators shall be provided at site-specific permitting, in particular with respect to matters that relate to the use of BAT to minimise radioactive discharges (AP1000 OI02).

221 For example, Chapter 7 in this document provides more information on tritium production in aqueous discharges. Westinghouse claims that plant operation can significantly affect the amount of tritium produced and that the AP1000 design that optimises plant availability contributes to minimising tritium production. Management techniques such as operator training which optimise operations are relevant to reducing the production of tritium. Optimising plant availability to minimise plant shutdowns and tritium production will be a matter for future Operators of the AP1000 reactor. We will continue to seek assurances that the hand over between Westinghouse and future Operators will address this matter. On the basis of the above information, with the arrangements for transfer of knowledge considered satisfactory for GDA, we consider that AP1000 OI02 can be closed out. These arrangements will be assessed in more detail at site-specific permitting.

222 **We conclude that Westinghouse has 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.

223 West Somerset Council and Sedgemoor District Council (GDA154) provided one set of answers to our consultation questions for both designs. The comment they provided in response to management systems is considered applicable to the AP1000 design. It noted ' *We have no fundamental observations with regard to the conclusion (made by the EA on knowledge transfer for EDF AREVA, noting our conclusion was the same for Westinghouse), 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*'.

224 The scrutiny of management systems is an aspect of permitting by Environment Agency and licensing by ONR that is carried out at the site-specific stage. There will be specific requirements under both ONR's licence and our permit conditions to maintain appropriate management systems.

225 A respondent (GDA124) 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?*'.

226 At this stage, the future operator for the AP1000 reactor is not known and therefore the management system has not been specified. These questions can be answered more fully during the site-specific phase when the permit and licence applications are made, by the future operator.

6 Integrated waste strategy

6.1 Conclusions

227 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.

228 **We have concluded that:**

a) **Westinghouse has provided a reasonable radioactive waste and spent fuel strategy for all waste streams that an AP1000 will typically produce.**

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

c) **The AP1000 design facilitates decommissioning, and uses BAT to minimise decommissioning waste and the impacts on people and the environment of decommissioning operations.**

229 As part of our assessment, we identified the following assessment finding:

a) The future operator shall provide at the detailed design stage, an updated decommissioning strategy and decommissioning plan (UK AP1000-AF01).

6.2 Background

230 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.

231 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.

232 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.

233 We summarise below the information presented in Westinghouse's submission on its 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.

234 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 Westinghouse's integrated waste strategy

235 Westinghouse's IWS outlines its current strategy for managing radioactive and non-radioactive waste, including spent fuel arising from operations and decommissioning for the AP1000 reactor. The IWS does not include waste from construction activities. The IWS is a companion document to the UK AP1000 environment report (ER) and the radioactive waste management case (RWMC) evidence reports for ILW and High Level Waste (HLW).

236 A schematic of the AP1000 reactor's waste management strategy can be found in Figure 3.5-1 of the ER.

237 Westinghouse's IWS states that it relates to all waste and all material that could become waste, both radioactive and non-radioactive. It claims in its IWS that the requirements of the waste management hierarchy are inherent in many aspects of the AP1000 design. It also claims that it has not identified any waste that is incompatible with current or developing disposal techniques.

238 Westinghouse claims in its ER that its IWS is consistent with the key BAT management factors for optimising releases from nuclear facilities shown in Table 3.1-1 in the ER. One of these factors stated by Westinghouse is to 'concentrate and contain environmentally persistent or bio accumulative emissions'. Features of the AP1000 design that address this factor have been added to Table 3.1-1 of the ER. (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 which involves the direct discharge of gaseous or liquid radioactivity into the environment, DECC, 2009a). The Institution of Mechanical Engineers (GDA146) responded to our consultation saying that it fully supports the principle of 'concentrate and contain' as the preferred process for the radioactive waste strategy and consider this to be the most suitable option for future reactors. Stop Hinkley (GDA159) 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.*' 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.

239 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 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. Westinghouse provided two documents - one for ILW and one for HLW - that it claims demonstrate that suitable RWMCs can be prepared by the site licensee in the future. These documents were both updated by Westinghouse in December 2010 and again in March 2011 (see Schedule 1 of Annex 1).

240 Westinghouse states in its IWS that its strategy for LLW is to collect and transfer it to its radwaste building where it will be sorted and segregated and, wherever possible, decontaminated. It also states that the AP1000 design features and operating regimes will reduce the volumes of LLW generated. Westinghouse expects that the future utility operator will dispose of LLW to the LLWR.

241 Westinghouse states in its IWS that the AP1000 design minimises the production of ILW. Its strategy for dealing with ILW is to process the waste into a stable form using mobile facilities and then to store on-site in the ILW store. It will be disposed of to the ILW repository when it has been developed.

242 Westinghouse states in its IWS that its strategy relating to radioactive liquids is to treat them to reduce activity, using BAT as much as practicable, and to discharge to the environment following a suitable monitoring period.

243 Westinghouse states in its IWS that its strategy relating to radioactive gaseous discharges is to treat as much as practicable using AP1000 systems, and then to monitor and release to the environment. Stop Hinkley (GDA159) 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*'. 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).

244 The ER is consistent with recent government statements (BERR, 2008a) as Westinghouse has stated in Section 3.5.8.2 that ILW will be stored on site until a national ILW repository becomes available.

245 The IWS takes into account statutory guidance concerning the regulation of radioactive discharges into the environment (DECC 2009a). In particular, Westinghouse has used the principle of 'concentrate and contain' in its AP1000 design.

246 Maldon Town Council (GDA59) 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.

247 Maldon Town Council (GDA59) 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 is our assessment and consultation.

248 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 in Annex 8.

249 Greenpeace (GDA152) 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 AP1000 will typically produce and that it is consistent with recent government statements (BERR, 2008a).

250 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 AP1000 will typically produce are similar to those from existing nuclear power plants.

251 Additionally, at our stakeholder seminar, the following comment was made on the AP1000 design: 'Evidence required to demonstrate that the design uses BAT. For instance visibility required on the process that has been undertaken to optimise radioactive waste minimisation and management facilities.' Studsvik UK Ltd (GDA132) also commented that BAT needs to be applied to the waste treatment options as well. Westinghouse has published its submission on its website which includes the AP1000 BAT assessment, and the radioactive waste treatment options study report.

252 Several respondents, including; individual respondents (GDA26, GDA85), the Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA71), Springfields Site Stakeholder Group (GDA97), Horizon Nuclear Power (GDA128) and the Institution of Mechanical Engineers (GDA146) said that they were satisfied with our conclusions on the IWS. Springfields Site Stakeholder Group (GDA97) said that it assumes that the strategy is consistent with waste hierarchy principles. We confirm that it is.

253 Westinghouse UK (GDA110) said that it agreed with our preliminary conclusions and that it was committed to resolving any outstanding issues within the GDA process.

254 **We have concluded that:**

a) **Westinghouse has provided a reasonable radioactive waste strategy for all waste streams that an AP1000 reactor will typically produce.**

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

6.4 Spent fuel strategy specifics

255 Westinghouse's IWS outlines its current strategy for managing radioactive and non-radioactive waste, including spent fuel arising from various stages of the lifecycle for AP1000, such as operation and decommissioning.

256 Section 3.5.1 of the ER provides an overview of the IWS that Westinghouse has developed to ensure that radioactive waste and materials generated, including spent fuel, are managed to be compatible with anticipated future NDA facilities for disposal. Westinghouse has assumed that it will be able to use current practices for spent fuel packaging when the AP1000 is in operation as NDA has not been able to provide information on the spent fuel packages it will accept. These assumptions relate to container designs and sizes and acceptable waste forms for spent fuel assemblies. Westinghouse continued to liaise with NDA on these

matters during the GDA process.

257 The strategy proposed by Westinghouse for managing spent fuel following its removal from the reactor, is to transfer the spent fuel to the spent fuel pool for storage and initial cooling for a period of some years, although current proposals indicate this cooling period might be reduced. The fuel would then be transferred to an interim spent fuel dry store until a geological disposal facility becomes available for direct disposal. More detailed information on new and spent fuel, including spent fuel management proposals is presented in chapter 11.

258 Westinghouse's proposals for interim dry spent fuel storage are based on the Holtec International HI Storm 100U underground system. There are a large number of independent spent fuel storage installations in the United States that are licensed and operating for dry spent fuel storage. These systems are also used in Europe to maintain the fuel in a dry inert atmosphere.

259 The Institution of Mechanical Engineers (GDA146) indicated its support for the specification of the Holtec International HI Storm 100U underground system for the interim storage of spent fuel.

260 Maldon Town Council (GDA59) noted it was satisfied with the strategy for pool storage, but they were '*not sure on strategy of dry spent fuel*' storage.

261 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.

262 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'*.

263 We consider that sufficient information for spent fuel management strategy is provided for GDA, and more information is provided in Chapter 11.

264 Westinghouse produced the RWMC evidence report to demonstrate how it could meet regulatory expectations, and identified the information required to produce the RWMC for spent fuel (HLW). 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 evidence report outlined more information on the plans for longer term interim spent fuel storage, and identified areas where more information was needed including future research requirements. The evidence report for HLW was updated by Westinghouse in December 2010.

265 The IWS notes that there is a spent fuel interim store to store all spent fuel assemblies generated by the reactor until the end of this century before final disposal. The IWS includes assumptions that spent fuel will be declared as waste and will not be reprocessed, and that it will be stored on-site and then disposed of to the geological disposal facility.

266 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, and the potential for refurbishment of the store(s).

267 The time period for spent fuel storage was raised in consultation responses. West Somerset Council and Sedgemoor District Council (GDA155) provided one set of answers to our consultation questions for both designs, but generally commenting on the EPR proposals. It noted for the UK EPR that the specific proposals for storage are for at least 100 years after the spent fuel is first emplaced in the store. Stop Hinkley (GDA157) noted its response is focused on the UK EPR design but that many of their points are general and would apply equally to the AP1000. It refers to a period of 160 years for on-site storage of fuel - 100 years for onsite 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*'.

268 Stop Hinkley (GDA159) also raised issues for high burn up fuel and length of storage. This is considered in chapter 11.

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

270 West Somerset Council and Sedgemoor District Council (GDA155) 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.

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

272 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. Westinghouse provided additional information, 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.

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

274 Westinghouse provides information in the BAT report on the measures it has incorporated in the design and use of fuel materials, and reactor controls in order to retain activity in the fuel.

275 Information is provided in Westinghouse's IWS about decommissioning waste and specific features of the AP1000 plant that have been designed to facilitate decommissioning. The IWS notes the longer term interim spent fuel store will be decommissioned following transfer of spent fuel to the GDF, and provides some general information on decommissioning of the store. The Institution of Mechanical Engineers (GDA146) noted their approval that the interim storage facility has been designed with decommissioning in mind, and commented that it '*awaits further details in Step 4*'. Further information on decommissioning is considered in the next section.

276 The IWS is consistent with recent government statements (BERR, 2008a) in relation to spent fuel, as Westinghouse has made the following assumptions:

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

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

277 Support for our conclusions on spent fuel management strategy came from an individual respondent (GDA26) '*I am satisfied with your conclusions*'. Also support was noted from Ingleby Barwick Town Council (GDA39), and other individual respondents (GDA14, GDA85).

278 Support for our conclusions on spent fuel management strategies came from the Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA71). It 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 (GDA146). Springfields Site Stakeholder Group (GDA 97) indicated their support '*in agreement with the preliminary conclusions, assuming they are consistent with the waste hierarchy principles*'. We consider our conclusions are consistent with the waste hierarchy principles.

279 Suffolk Coastal District Council (GDA165) noted 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 commented about the longer term potential for the degradation of spent fuel, this is considered in chapter 11.

280 Horizon Nuclear Power (GDA128) responded that it welcomes and supports our conclusions that Westinghouse has provided a reasonable strategy for spent fuel management.

281 **We have concluded that:**

a) **Westinghouse has provided a reasonable strategy for managing spent fuel that will be produced by the AP1000 reactor.**

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

6.5 Decommissioning specifics

282 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 (BAT) 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.

283 Westinghouse claims that it has demonstrated the end of life activity of decommissioning, and has taken the current experience of decommissioning activities into account in the design and layout of the AP1000 in chapter 20 of its European DCD. It states that this enables the utility to develop a decommissioning strategy. In UKP-GW-GL-795, Revision 0, "UK AP1000 NPP Decommissioning Plan", March 2011, Westinghouse provides information on an AP1000 outline decommissioning plan. It claims that this plan demonstrates the technical and practical feasibility of one method by which the AP1000 can be easily decommissioned. Westinghouse also provides information on decommissioning and end of life aspects in Chapter 27 of its PCSR.

284 Westinghouse states in its IWS that, within the design of the AP1000, there are

many features that facilitate the eventual decommissioning of the plant. For example:

a) Reduced equipment numbers reduce the amount of waste that needs managing.

b) Carefully selecting materials reduces activation of equipment and structure.

c) Reduction in activated corrosion products by improved control of primary circuit water chemistry and suitable dosing regimes; for example, zinc acetate.

285 We noted in our consultation document, that ONR were requesting further information from Westinghouse 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). Westinghouse provided this additional information in December 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 AP1000, including decommissioning. The AP1000 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 AP1000-AF01).

286 We note that ONR has four assessment findings associated with the decommissioning of an AP1000. During GDA, ONR agreed that Westinghouse could defer the development of some aspects of decommissioning until a licensee had been identified. Therefore, three assessment findings are associated with the outstanding work. They are for the development of a set of decommissioning principles; to look at the possible affects of a delay in decommissioning; and to identify the potential hazards and challenges associated with decommissioning. The other assessment finding is 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 all of these assessment findings.

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

288 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 Westinghouse (see Schedule 1 of Annex 1).

289 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)

290 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 with our REP DEDP2, initial decommissioning plans should be prepared during the design and construction of new facilities.

291 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 Westinghouse has included learning from experience principles.

292 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 (BAT) 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 Westinghouse has considered the reuse of materials.

293 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. Ingleby Barwick Town Council (GDA39) also provided a similar response, as it said that the preliminary conclusions are okay as far as they go at this time but further discussion needs to take place with Westinghouse on decommissioning as this issue will figure prominently in the nuclear debate. As mentioned above, since our consultation, we have received additional information from Westinghouse (see Schedule 1 of Annex 1) that we have reviewed and considered in making our decision.

294 Stop Hinkley (GDA159) 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*'. Stop Hinkley noted their response is focused on the EPR design but that this point would apply equally to the AP1000 design.

295 Horizon Nuclear Power (GDA128) provided the following response: '*We appreciate that the EA's conclusions on decommissioning in the consultation document are focussed on the design of the AP1000 and it is right and proper that Westinghouse should respond to this aspect since this is under their full control. However, we are also aware that the EA has requested information from Westinghouse 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.

296 The Institution of Mechanical Engineers (GDA146) responded to our consultation with the following comment:

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.*'

297 The Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA71) notes our reservation (in our consultation document) on decommissioning the AP1000 is understandable. It commented that uncertainty around the decommissioning strategy also presents an issue which is likely to undermine arguments to secure public acceptability.

298 Westinghouse UK (GDA110) said that it agrees with our preliminary conclusions and that it is committed to resolving any outstanding issues within the GDA process.

299 We asked for additional information from Westinghouse on decommissioning (which, as mentioned above, it 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 AP1000 can be decommissioned in an environmentally acceptable manner. We have concluded that decommissioning is no longer a GDA Issue.

300 **We conclude that the AP1000 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 provide at the detailed design stage, an updated decommissioning strategy and decommissioning plan (UK AP1000-AF01).**

7 Best available techniques to minimise production of radioactive waste

7.1 Conclusions

301 Our conclusion remains unchanged since our consultation.

302 **We conclude that overall the AP1000 utilises the best available techniques (BAT):**

a) **to prevent and minimise production of gaseous and aqueous radioactive waste during routine operations and maintenance and from anticipated operational events;**

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

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

a) Future operators shall, at the detailed design phase, provide a BAT assessment to demonstrate whether boron recycling represents BAT for their location. (AP1000-AF02)

b) 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. (AP1000-AF03)

c) Future operators shall, before the construction phase, provide a BAT assessment to demonstrate that the design and capacity of secondary containment proposed for the monitor tanks is adequate for their location. (AP1000-AF04)

7.2 Background

304 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).

305 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 concerns:

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.

306 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.

307 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.

308 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).

309 We received nine responses on the use of BAT to minimise the production of radioactive waste. Six of those responses supported our conclusion, others sought clarification of some issues.

310 Several respondents 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. Our guidance '*Principles of optimisation in the management and disposal of radioactive waste*' provides a full explanation of BAT. (Environment Agency, 2010f)

311 A query from our stakeholder seminar was whether any '*BAT were new*' or were all '*tried and tested*'. The AP1000 uses techniques that have been used in other reactors or have been developed from existing techniques.

312 Another query from our stakeholder seminar was where information on all radionuclides generated by the AP1000 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 Westinghouse in their Environment Report, in particular see Tables 3.3-6, 3.3-7, 3.3-8 and 3.4-6.

7.3 Sources of radioactivity

313 This section describes the sources of radioactive materials in the AP1000 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)

314 Radioactive materials within the UK AP1000 are mainly (ERs3):

a) fission products created in the fuel that may pass through the fuel cladding by diffusion or through leaks and enter the coolant;

b) dissolved or suspended corrosion products or other non-radioactive materials in the coolant that can be activated by neutrons as the coolant passes through the reactor core.

315 Westinghouse provides information in its BAT final assessment report (AP1000 BAT) for the following radionuclides or groups of radionuclides:

a) tritium;

b) carbon-14;

c) nitrogen-16;

d) strontium-90;

e) iodine-131;

f) caesium-137;

g) plutonium -241;

h) noble gases;

i) other beta emitting particulate radionuclides which are produced by the activation of non-radioactive material. This group includes cobalt-58, cobalt-60, iron-55 and nickel-63.

316 We assessed the information provided and concluded that Westinghouse has identified those radionuclides which either:

a) Contribute significantly to the amount of activity (Becquerel - Bq) in waste disposals;

b) Contribute significantly to potential dose 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.

317 Information Westinghouse presented in the AP1000 BAT final assessment report is summarised below.

7.3.1 Tritium

318 Tritium is one of the most abundant radionuclides present in the coolant and contributes significantly to activity in waste disposals. It is created by (AP1000 BAT Form 1):

a) unavoidable ternary fission of the uranium fuel. The tritium formed is initially contained within the fuel cladding but may diffuse into the coolant. The rate of tritium released into the coolant depends on reactor power. Westinghouse claim that the zirconium fuel cladding (ZIRLO) used in the AP1000 is more effective at reducing diffusion than other cladding materials. Westinghouse uses a 10 per cent in-core tritium release to the coolant as the design basis, which results in producing 63 TBq of tritium per 18-month cycle. Westinghouse uses a two per cent release of tritium to the coolant as the best estimate of tritium production, which results in producing 13 TBq of tritium per 18-month cycle.

b) activation of the boron which is used as a burnable absorber either in discrete burnable absorber rods or as integral fuel burnable rods. The tritium will be produced within the cladding and may diffuse into the coolant. Westinghouse predicts the amount of tritium produced this way will be 10 TBq per 18-month cycle (design basis) or 2 TBq per 18-month cycle (best estimate).

c) activation of boron-10 which is present as boric acid in the coolant. Boron is used to control the reactivity of the reactor. Westinghouse claims the AP1000 uses two techniques to minimise the amount of tritium produced:

   i) grey rod clusters for load following minimises the amount of coolant boron needed for reactor control and the need for changes to boron concentration

(ERs3.2.8);

ii) burnable poisons (a boride coating or incorporation of gadolinium oxide within some fuel pellets) reduces the amount of boron required.

Westinghouse predicts the amount of tritium produced by this method will be 27 TBq per 18-month cycle.

d) activation of lithium-6 and lithium-7 present in the lithium hydroxide which is used for chemistry control of the coolant to offset the corrosive effect of boric acid. Westinghouse claims that using lithium hydroxide enriched to 99.9 per cent of lithium-7 in the AP1000 minimises production of tritium (lithium-6 produces greater quantities of tritium than lithium-7). Westinghouse predicts the amount of tritium produced by this method will be 6 TBq per 18-month cycle.

e) activation of deuterium in the reactor coolant (deuterium is an isotope of hydrogen which is naturally present in water at 0.015 per cent). We accept that producing tritium from deuterium is unavoidable and there are no available techniques to minimise its production. Westinghouse predicts tritium produced by this technique will be 0.15 TBq per 18-month cycle.

319 A respondent, '*Stop Hinkley*' (GDA159), had concerns on the use of a burnable poison. The term poison used for nuclear reactors means that a material, such as gadolinium oxide, 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 poison 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 poison is completely contained within fuel pins and should not be discharged to the environment to cause any health impact.

320 An individual respondent (GDA89) thought the consultation document was unclear on the potential use of enriched boric acid to reduce tritium production. We have rewritten the text on the subject below:

321 Westinghouse have considered use of boric acid enriched with boron-10 in place of natural boric acid (ERs3.4.4.2). As boron-10 is the effective moderator the quantity of enriched boric acid could be reduced by a factor of three compared to natural boric acid. This would not affect tritium production from boron-10 as the same amount of boron-10 is involved regardless of acid type. However reducing the amount of boric acid would enable addition of lithium hydroxide (that balances the pH) to be reduced with consequent reduction in production of tritium from lithium-7. Westinghouse claim the increased cost of enriched boric acid (200 times cost of natural acid) is unjustified as:

a) the quantity of boron-10 needed in the AP1000 has been reduced by use of grey rods for mechanical reactor control and other methods;

b) only small quantities of lithium hydroxide are needed as it is a strong base and boric acid is a weak acid, also 99.9 percent lithium-7 hydroxide will be used, giving low potential for tritium production.

322 The production of tritium from lithium-7 predicted above was 6 TBq out of a total of 110 TBq for the design basis 18-month cycle. On that basis we conclude that potential for reduction of tritium by use of enriched boron-10 is limited and accept the Westinghouse argument for not using the enriched acid.

323 Westinghouse considered the use of boron recycle to minimise production of tritium in the AP1000 in the BAT options appraisal (AP1000 BAT section 4.3.3.1.2). The AP1000 design does not include boron recycle and any boron present in effluents

will be discharged to the sea.

324 Westinghouse claims that boron recycling requires a significant amount of additional equipment and because recycling can only occur in the next fuel cycle, borated water would need to be stored for long periods. The operation, maintenance and storage of borated water is likely to increase occupational radiation exposure and Westinghouse does not consider this to be ALARP.

325 Westinghouse claims that the AP1000 design minimises production of aqueous radioactive waste. In particular, using mechanical rather than chemical controls reduces the quantity of boron needed to control reactivity.

326 Apart from the discharge of radioactivity, there is, to protect the marine environment, an Environmental Quality Standard relating to the concentration of boron in seawater. Westinghouse claims the AP1000 discharge of boron would have a negligible effect on receiving waters. Westinghouse concludes that boron discharge rather than boron recycle is BAT. (ERs3.4.4.3)

327 We accept that in terms of chemical boron discharge there is little benefit to the use of boron recycle. However, a boron recycle system would enable coolant to be recycled and reduce the overall aqueous waste volume entering the Liquid radioactive waste system (WLS). We say later in this document in chapter 9 that future operators will need to show how they will treat aqueous wastes that are not compatible with ion exchange and that evaporation needs to be considered. Lower aqueous waste volumes might be a factor in potential use of an evaporator as it would reduce the quantity of evaporator bottoms needing disposal. The reduction in waste volume from use of boron recycle will be a factor to consider in assessment of the use of evaporation required by assessment finding AP1000-AF04 (see chapter 9).

328 We accept the current Westinghouse justification for not using boron recycle. However there are location specific circumstances where boron recycle may have application to reduce volume of discharge and both its radioactive and non-radioactive wastes concentrations. If boron recycle were employed then the case for use of enriched boric acid may change. We have therefore included an assessment finding:

a) Future operators shall, at the detailed design phase, provide a BAT assessment to demonstrate whether boron recycling represents BAT for their location. (AP1000-AF02)

329 Westinghouse concludes that the following techniques are BAT to minimise tritium production in the AP1000:

a) using lithium-7 rather than lithium-6;

b) using zirconium fuel cladding;

c) using grey rods.

330 Westinghouse predicts the total amount of tritium produced from an AP1000 to be 110 TBq per 18-month cycle (design basis) or 49 TBq per 18-month cycle (best estimate).

331 **Our assessment concluded that Westinghouse has demonstrated that BAT is used to minimise the production of tritium in the AP1000 at this time. Our assessment identified the following assessment finding:**

a) **Future operators shall, at the detailed design phase, provide a BAT assessment to demonstrate whether boron recycling represents BAT for their location. (AP1000-AF02)**

332 The Health Protection Agency (GDA89) recommended that a BAT assessment on

boron recycling should consider the production of tritiated methane as well as tritium gas and tritiated water. We accept this and will ensure tritiated methane is covered in any assessment.

7.3.2 Carbon-14

333 Carbon-14 contributes significantly to both activity disposals and potential dose. It is created by the following mechanisms (AP1000 BAT Form 2):

a) Neutron activation of oxygen-17, which is a naturally occurring stable isotope of oxygen in the coolant. Westinghouse claims it minimises the production of carbon-14 by eliminating free oxygen in the coolant. Westinghouse predicts the amount of carbon-14 produced from oxygen-17 to be 552 GBq y^{-1}.

b) Neutron activation of nitrogen-14 dissolved in the coolant. The AP1000 uses lithium hydroxide to control coolant pH as opposed to hydrazine which contains nitrogen and is used in some other designs. Using lithium hydroxide instead of hydrazine reduces the amount of nitrogen in the coolant and the amount of carbon-14 produced by this mechanism. Westinghouse has considered using argon as the cover gas for the coolant water supply tanks to minimise the dissolution of nitrogen. This would make the systems more complex and costly, and Westinghouse do not consider the use of argon cover gas to be BAT for the AP1000. Assuming 15 ppm of nitrogen in the coolant Westinghouse predict the production of carbon-14 from nitrogen-14 to be 110 GBq y^{-1}.

c) The neutron activation of nitrogen-14 in fuel. Nitrogen-14 in the fuel is minimised during the fabrication process during which the fuel rods are pressurised with helium which expels nitrogen from the fuel.

d) Carbon-14 is produced by the neutron activation of oxygen-17 and nitrogen-14 in stainless steel structural materials. However, Westinghouse claims that the carbon-14 produced by these methods will remain in these materials.

334 Westinghouse provides an options appraisal for techniques to minimise production of carbon-14 in the AP1000 in its AP1000 nuclear power plant BAT assessment. Westinghouse concludes that the following techniques are BAT to minimise carbon-14 production in the AP1000:

a) oxygen scavenging;

b) control of nitrogen in fuel by use of helium pressurisation;

c) pH control by lithium hydroxide;

d) using electro-deionisation to remove dissolved carbon dioxide gas from the coolant.

335 Assuming 15 ppm nitrogen in the coolant Westinghouse predicts the total production of carbon-14 to be 662 GBq y^{-1}.

336 **Our assessment concluded that Westinghouse has demonstrated that BAT is used to minimise the production of carbon-14 in the AP1000.**

7.3.3 Noble gases

337 Noble gas radionuclides such as krypton-85, krypton-85m, xenon-133 and xenon-133m are fission products and are produced by fission of the uranium in the fuel. They are normally contained within the fuel cladding. However, if there are any fuel defects, these gases can enter into the 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. (AP1000 BAT Form 8).

338 Even though there may be no defective fuel pins, natural uranium contamination of core construction materials and the fuel cladding, as well as enriched uranium contamination of external cladding surfaces during manufacture (tramp uranium) can also be a source of fission products in the coolant during power operations. Noble gas radionuclides dissolved in the coolant will be removed by degassing in the chemical and volume control system (CVS) and sent to the gaseous radioactive waste system (WGS).

339 Westinghouse claims that fuel leak rate in operating plants similar to the AP1000 is much less than the AP1000 design basis value of 0.25 per cent which was used to during aqueous and gaseous radioactive waste system design and that current fuel design has been improved, both in terms of the integrity of fuel rods and the robustness of the fuel assembly with respect to vibration of the rods within the assembly (ER s3.2.4).

340 Westinghouse say that the AP1000 GDA design basis is using Westinghouse fuel type 17RFA. Westinghouse say on fuel integrity: *'Since the implementation of the Westinghouse 17x17 RFA in 1998 the overall leakage rate of this design, incorporating all the Westinghouse debris protection features, is 0. The overall leakage rate, on a rod basis, of the basic RFA fuel product including designs that do not use all the debris protection features is less than 10^{-5}'* (ERs3.2.4)(less than 10^{-5} means less than 10 in a million or 1 in 100,000)

341 Westinghouse concludes that minimising fuel defects in operation, using reactor operating regimes that minimise the likelihood of damage to the fuel, and the location and removal of leaking fuel pins during refuelling is BAT to minimise noble gas production in the AP1000.

342 **Our assessment concluded that the average fuel failure rate quoted by Westinghouse is indicative of use of BAT to minimise the release of noble gases from the fuel in the AP1000. 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 Westinghouse type 17RFA fuel assemblies in the AP1000 reactor.**

343 **Argon-41** is produced by the activation of natural argon-40 in air surrounding the reactor within the containment building. Westinghouse predicts that 1,300 GBq y^{-1} of argon-41 will be produced in the AP1000 reactor. Argon-41 is collected by the ventilation system and discharged through the main vent without treatment.

344 **We conclude that, taking into account that the production of argon-41 is unavoidable, its short half life (109 minutes) and low radiological impact, it is not proportionate to assess BAT in detail for argon-41. Discharges of argon-41 will be monitored and measured with other noble gases at the main plant stack and the turbine building stack.**

7.3.4 Iodine radionuclides

345 Iodine radionuclides are formed in the fuel by fission and can be released into the coolant as a result of defects in the fuel. In addition fission of uranium found on fuel and other surfaces (tramp uranium) can undergo fission and iodine radionuclides can be released into the coolant. The presence of iodine radionuclides in gaseous discharges is another indicator of fuel defects.

346 We accept that there are no techniques to prevent the production of iodine

radionuclides within the fuel pins (AP1000 BAT Form 5).

347 The majority of iodine radionuclides produced will form compounds and remain in the liquid phase of effluents from the CVS. A small fraction will remain as elemental iodine and will be degassed in the CVS and passed to the WGS. Any leaks from the primary coolant system could also result in iodine radionuclides being found in the containment atmosphere.

348 Westinghouse concludes that the following techniques are BAT to minimise iodine-131 (and other iodine radionuclides) production in the AP1000 reactor:

a) Minimisation of fuel defects in operation – reactor operating regimes are used which minimise the likelihood of damage to the fuel and leaking fuel pins are located during refuelling and removed. See also information on fuel integrity in the noble gases section above.

b) Control of uranium contamination on external surfaces of fuel (tramp uranium) in fuel manufacture and fabrication.

349 **Our assessment concluded that Westinghouse has demonstrated that BAT is used to minimise the production of iodine-131 (and other iodine radionuclides) in the AP1000 reactor.**

7.3.5 Other radionuclides

350 **Nitrogen-16** - is produced by activation of oxygen-16 in the reactor coolant. There is no practicable way to reduce its formation. However, its short half-life of 7.13 seconds means that discharges to the environment will be insignificant. (AP1000 BAT Form 3)

351 We consider that minimising the production of nitrogen-16 at source is mainly a matter for ONR as the short half life of nitrogen-16 means its key impact is on occupational dose.

352 We do not consider nitrogen-16 further in our assessment.

353 **Strontium-90** is a fission product normally contained within the fuel cladding. If there are any fuel defects strontium-90 can enter into the primary coolant. Westinghouse has not carried out an optioneering assessment for preventing or minimising strontium-90 at source, but it does claim that minimising fuel defects is key to minimising the production of strontium-90. (AP1000 BAT Form 4)

354 We consider that the production of strontium-90 is unavoidable, however we recognise that techniques to minimise fuel defects (which are used to minimise the production of other radionuclides) will also minimise the production of strontium-90.

355 **Our assessment concluded that Westinghouse has demonstrated that BAT is used to minimise the production of strontium-90 in the AP1000 reactor.**

356 **Caesium-134** and caesium-137 are fission products normally contained within the fuel cladding. If there are any fuel defects caesium radionuclides can enter the primary coolant. Fission of uranium contamination in the reactor (tramp uranium) can also be a source of caesium-134 and caesium-137. Caesium is highly soluble and, if present in the coolant, will eventually be treated in the liquid radioactive waste treatment system (WLS). Detecting caesium radionuclides in aqueous radioactive waste disposals provides a useful indication of fuel integrity.

357 Westinghouse concludes that the following techniques are BAT to minimise caesium-137 production in the AP1000 (AP1000 BAT Form 6):

a) Minimisation of fuel defects in operation – reactor operating regimes are used which minimise the likelihood of damage to the fuel, and leaking fuel pins are located during refuelling and removed.

b) Control of uranium contamination on external surfaces of fuel (tramp uranium) in fuel manufacture and fabrication.

358 **Our assessment concluded that Westinghouse has demonstrated that BAT is used to minimise the production of caesium-137 in the AP1000 reactor.**

359 **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. 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.

360 **Cobalt-58** is formed by the activation of nickel-58, a stable isotope of nickel, which is a major constituent of the AP1000 steam generator tubes and the stainless steel used to fabricate the core and the reactor pressure vessel components. Westinghouse claims it minimises the potential for the creation of cobalt-58 in the AP1000 by:

a) specifying metals that resist the corrosive effect of the coolant thus reducing corrosion products available to be activated;

b) only using nickel-based alloys where component reliability may be compromised by the use of other materials, for example the steam generator tubes;

c) pre-passivation of the steam generator to develop a single, chromium-rich layer which reduces corrosion product release.

361 **Cobalt-60** is formed by the activation of cobalt-59 in the reactor steel. Cobalt is also found in hard-wearing alloys (stellites) which may be used on hardfacing components. Westinghouse claims it has minimised the amount of cobalt-60 produced in the AP1000 by minimising the amount of cobalt bearing materials used in the design using the following techniques:

a) using low or zero cobalt alloys for hardfacing materials in contact with coolant unless necessary for reliability considerations;

b) limiting cobalt content of components in contact with coolant;

c) specifying low cobalt content (0.015 per cent) tubing for the steam generator.

362 We note that ONR's radiological protection assessor has raised a finding which requires the licensee to demonstrate that the content of cobalt has been reduced So Far As Is Reasonably Practicable (SFAIRP) as a result of concerns regarding operator radiation exposure for work within containment.

363 **Iron-55** is formed by the activation of the stable isotope iron-54 found in the reactor steel. Minimising its use is not practicable. Controlling corrosion by choosing appropriate materials and the general measures described below will minimise creation of corrosion products that may be activated.

364 **Nickel-63** is formed by the activation of the stable isotope nickel-62 found in nickel

alloys, in particular the steam generator tubes. Minimising the production of nickel-63 is achieved by the same techniques as for cobalt-60.

365 Westinghouse uses several general techniques that ensure low corrosion rates, which it claims are BAT to minimise the production of activated corrosion products in the AP1000 (AP1000 BAT Form 9):

a) good quality assurance and control systems for manufacture and construction;

b) piping design such as the use of pipe bends instead of elbows and making welds smooth to minimise corrosion and to avoid crud traps;

c) control of coolant to reduce corrosion. The coolant chemistry is selected to minimise corrosion and coolant routinely analysed to confirm it meets specification and the CVS is used to add chemicals to the coolant such as:

   i) lithium hydroxide to control pH;

   ii) hydrazine to scavenge oxygen during start-up;

   iii) dissolved hydrogen to control radiolysis reactions involving hydrogen, oxygen and nitrogen during power;

d) purifying coolant by filtration and ion exchange in the CVS;

e) control of chemical quality of make-up water and chemical additives;

f) zinc injection (at between 5 to 40 parts per billion) into the primary coolant to (ER s2.6.6):

   i) produce more stable corrosion films that reduce ongoing corrosion;

   ii) make corrosion products less likely to deposit reducing crud related issues.

366 **Our assessment concluded that Westinghouse has demonstrated that BAT is used to minimise the production of activation products in the AP1000 reactor.**

367 Westinghouse provided additional information on zinc injection after our consultation. Document LTR-AP1000-10-490 dated 29 July 2010 provided information on the benefits of zinc injection in reducing corrosion. The information was supported by data from operating plant. Westinghouse state that zinc injection is now used on more than 59 PWRs worldwide. We assessed this information and reviewed ONR's more detailed assessment on this topic (ONR assessment report AP1000 - AR 11/008) and concluded that zinc injection 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. **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. (AP1000-AF03)**

7.3.6 Radioactive actinides

368 Radioactive actinides are formed in the fuel and can enter the coolant as a result of fuel leaks. They are also formed in any trace surface contamination of the fuel pins by fuel (tramp uranium). They may enter the coolant and may be significant in terms of the impact of disposals as the majority are alpha emitters.

369 Westinghouse has not provided any information on the amount of alpha emitting radioactive actinides it expects the AP1000 reactor to produce. However, it lists the

following actinides as having a negligible annual discharge to the sea (ER Table 3.4-6): uranium-234, uranium-235, uranium-238, neptunium-237, plutonium-238, plutonium-239, plutonium-240, plutonium-242, americium-241, americium-243, curium-242 and curium-244.

370 Information has been provided about plutonium-241 which is a beta emitting actinide. The amount of plutonium-241 expected to be produced has not been given, however information has been provided about the average amount of plutonium-241 in aqueous discharges which is predicted to be 0.00008 GBq y^{-1}.

371 We accept that the production of plutonium-241 is an inevitable consequence of uranium fission reactions and cannot be prevented in the fuel. Westinghouse claims that the following techniques used in the AP1000 are BAT to minimise the quantity of plutonium-241 potentially present in the coolant:

a) improved cladding material and quality control in manufacture has greatly reduced the incidence of fuel pin failures (see also noble gases above);

b) control of uranium contamination in the manufacture of fuel pins;

c) minimising plant shutdowns;

d) ultrasonic fuel cleaning.

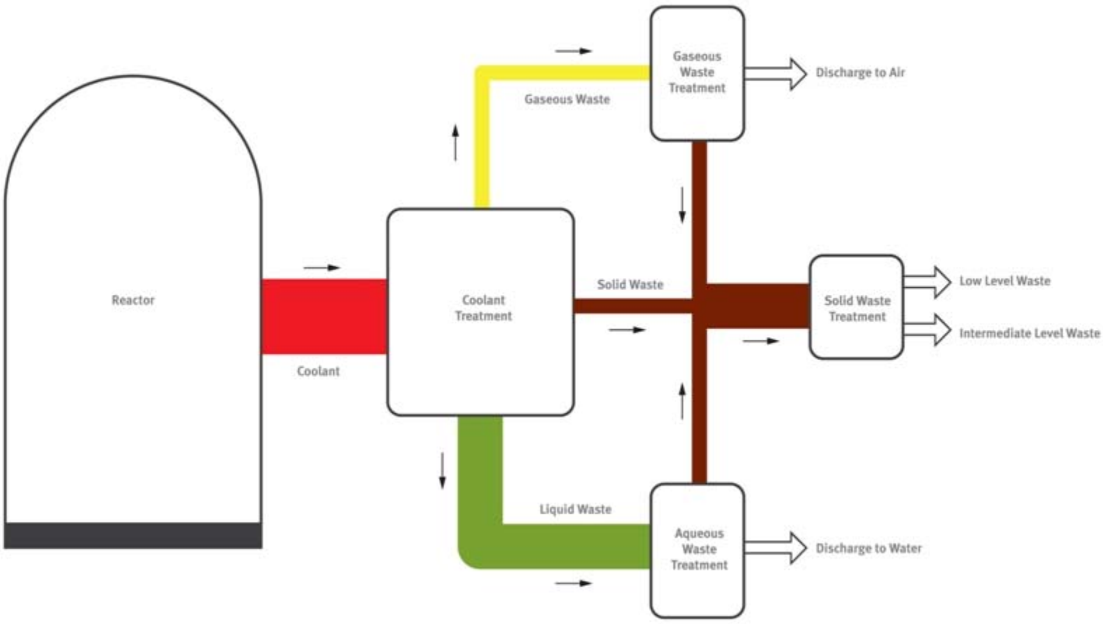
372 See also our section 11.4.1 on BAT for fuel design.

373 **Our assessment concluded that Westinghouse has demonstrated that BAT is used to minimise the production of plutonium-241 in the AP1000 reactor, and we accept that other actinides do not contribute significantly to annual discharges to the sea.**

7.4 Processing of radioactive materials in the AP1000

374 This section describes how radioactive materials are processed and handled in the AP1000. 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)

375 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, liquid and gaseous waste routes. The diagram below is used for illustrative purposes. 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 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

376 Gaseous radioactivity from radiologically controlled areas within the AP1000 is removed by ventilation systems to reduce occupational exposure. The ventilation systems discharge into the main plant vent.

7.4.1 Primary circuit – the reactor coolant system (RCS)

377 The reactor coolant system (RCS) includes the reactor, two steam generators, four coolant pumps and a pressuriser. The coolant is essentially water with boric acid added for long-term reactivity control of the reactor and lithium hydroxide to offset the corrosive effect of the acid. The RCS chemistry is controlled by sending a portion of the coolant to the chemical and volume control system (CVS).

378 The CVS (ER s3.2.7) is used to:

a) reduce boron concentration by let-down of coolant to the WLS and replacement with demineralised water;

b) manage lithium hydroxide to control pH of coolant;

c) manage hydrazine at plant start-up to scavenge oxygen;

d) manage hydrogen during power operations to eliminate free oxygen. Hydrogen added to control radiolysis product production and limit corrosion of fuel cladding / alloys by reactive species;

e) manage zinc acetate to minimise corrosion;

f) manage boric acid addition to the RCS.

379 The CVS also purifies the coolant to maintain low system radioactivity. The returning coolant flow is passed through a mixed bed demineraliser to remove

dissolved corrosion products. The mixed bed also acts as a filter to remove particulate corrosion products. The bed is sized to provide demineralisation for one cycle of operation but a second demineraliser is provided in case the operational bed becomes exhausted. A cation bed demineraliser is available to use in the event of fuel leaks and mainly removes caesium isotopes. Filters are installed downstream of the demineralisers for final removal of particulates and resin fines. The filter elements and spent demineraliser resins need to be replaced at intervals and become significant (possibly ILW) solid radioactive waste. We consider using filters and demineralisers in this system in the AP1000 contributes to BAT, with the benefit of reducing the radioactivity of liquid waste outweighing the generation of solid waste. (ER s3.2.10)

380 Iodine radionuclides will also be absorbed in the CVS mixed bed demineraliser. Noble gas removal is not normally necessary when fuel defects are within normally anticipated ranges. If noble gas removal is needed, the CVS can operate together with the WLS degasifier, see below. (ERs3.2.10).

381 The operation of the CVS is important to optimise the impact of radioactive disposals. We need assurance that Westinghouse will work with future Operators to inform their use of BAT. We have included this topic within chapter 5 of this document under 'Expectations for the operator's management system' where we have examined the arrangements for transfer of knowledge about the AP1000 design from Westinghouse to future operators. The other issue AP1000 OI-02 that we included in our Consultation Document has therefore been closed out.

382 ONR have included an assessment finding for the licensee to optimise the operation of the CVS and the liquid, gaseous and solid waste management processes to ensure that the risks associated with their operation and the management of resulting wastes are as low as reasonably achievable.

383 One respondent (GDA39) stressed that '*handover procedures from builder to operator on nuclear stations is critical'* in support of our other issue. As noted above, we have moved this issue to chapter 5 as it is only part of the handover arrangements we expect.

7.4.2 Secondary circuit

384 The secondary circuit contains boiler quality water that is made into steam in the steam generators. The steam drives turbines that generate electricity. The steam is condensed after passing through the turbines and the condensate water normally reused. In the event of any tube leaks in the SGs, the secondary circuit water could be contaminated with radioactivity, in particular with tritium. Radiation monitors are installed to detect contamination so that operators can take the necessary action. (ER s3.3.3)

385 Air in-leakage and non-condensable gases removed from the condenser after the turbine in the secondary circuit do not normally contain radioactivity (as noted above) and are discharged without treatment through the condenser air removal system to the turbine building vent. Any condensate not reused (the blowdown) will be collected in the Waste Water Retention Basin (WWRB). The contents of the WWRB are monitored before discharge, if any radioactivity is detected then the contents can be treated in the Liquid radioactive waste system.

7.4.3 Ventilation systems

386 Ventilation systems should include appropriate treatment systems to remove and

collect airborne radioactive substances before they are discharged to the air. (Our REPS ENDP16)

387 The containment air filtration system (VFS) serves the reactor containment building, the fuel handling area and some other controlled areas. Radioactive materials can be present in the ventilation air from trace leaks of coolant or from activation of argon normally present in air to argon-41. The VFS is normally only operated periodically to reduce detected airborne activity or to maintain containment pressure. (ERs3.3.2.2)

388 The VFS comprises two 100 per cent capacity systems, each with an inlet electric heater, a high efficiency particulate air (HEPA) filter bank, a charcoal iodine adsorber, a post-filter and an exhaust fan. Gaseous radiation monitoring equipment is located downstream of the VFS with an alarm to warn of abnormal releases.

389 The containment venting system includes a filtration system which provides the following functions:

a) intermittent flow of outdoor air to purge the containment atmosphere of airborne radioactivity during normal plant operation, and a continuous flow during hot or cold plant shutdown conditions to provide an acceptable level of airborne radioactivity before people enter.

b) intermittent venting of air into and out of the containment to maintain the containment pressure within its design pressure range during normal plant operation.

c) directs the exhaust air from the containment atmosphere to the plant vent for monitoring, and provides filtration to limit the release of airborne radioactivity at the site boundary within acceptable levels.

d) monitoring of gaseous, particulate and iodine concentration levels discharged to the environment through the plant vent.

390 The two exhaust air filtration units are located within the radiologically controlled area of the annex building. Each exhaust air filtration unit can handle 100 per cent of the system capacity. Each unit consists of an electric heater, an upstream high efficiency particulate air (HEPA) filter bank, a charcoal adsorber with a downstream post-filter bank, and an exhaust fan.

391 A radiation monitor is located downstream of the exhaust air filtration units in the common ductwork to provide an alarm if abnormal gaseous releases are detected.

392 During normal plant operation, the containment air filtration system is operated from time to time to purge the containment atmosphere as determined by the main control room operator to reduce airborne radioactivity or to maintain the containment pressure within its normal operating range.

393 The filtered exhaust air from the containment is discharged to the atmosphere through the plant vent by the exhaust fan. Radioactivity indication and alarms are provided to inform the main control room operators of the concentration of gaseous radioactivity in the containment air filtration system exhaust duct and gaseous, particulate and iodine concentrations in the plant vent.

394 Westinghouse provides a specification for its choice of HEPA filter elements in the ER Table 3.3-2. It claims these HEPA filters are BAT as they balance increased pressure drop (with increased energy use) and larger filter volume requiring disposal as LLW against performance. We accept this claim at present but will require performance data to confirm this at site-specific permitting. (ERs3.3.9.2)

395 The filtered exhaust air from the VFS is discharged to air through the main plant vent. The vent is monitored for radioactive discharges.

396 The Regulators jointly raised a Regulatory Observation (RO-AP1000-43) on Westinghouse regarding nuclear ventilation, in particular the radiologically controlled area ventilation system (VAS). We noted our concerns in the Consultation Document as a potential GDA Issue. Subsequently Westinghouse proposed some design changes for the AP1000 to comply with UK good practice described in "A*n Aid to the Design of Ventilation of Radioactive Areas*" (Nuclear Ventilation Forum, 2009), these are shown in the latest version (Revision 4) of the Environment Report (ERs3.3.2).

397 The VAS serves the fuel handling and other areas of the AP1000. The VAS consists of two separate sub-systems, the fuel handling area ventilation subsystem, and the auxiliary / annex building. In normal circumstances radioactivity is not expected to be collected by the VAS and, as described in our Consultation Document, it was discharged without treatment into the main plant vent unless radiation monitors divert it to the Containment ventilation System, VFS, on detection of radioactivity. The changes that have been made to the VAS and other nuclear ventilations systems, VHS and VRS:

a) Health Physics and Hot Machine Shop Ventilation System (VHS): the VHS fans will shut down on a High radiation signal and exhaust through the VFS, the airflow from the served spaces will then be reduced, but the exhaust will thus be HEPA filtered.

b) VHS: High efficiency filters in or at the individual machine tools will be replaced with HEPA filters.

c) Radwaste Building HVAC System (VRS): HEPA filtration will be added to the VRS exhaust from the radwaste building.

d) Radiologically controlled area ventilation system (VAS): Auxiliary building area radiation monitors will be added to the controls that isolate VAS and actuate VFS filtration.

e) VAS: HEPA filtration is added to the VAS subsystem serving the fuel handling area. This negates the potential for release through the VAS in case of equipment failure; there is a potential for corrosion product crud accumulated on spent fuel assemblies to become airborne.

398 We sought evidence that the design change proposals (DCPs) for ventilation were subject to Westinghouse due process for approval, and that the DCPs are robust in implementation in GDA. Westinghouse provided evidence in response to TQ-AP1000-1201 on the approved DCPs for ventilation:

a) APP-GW-GEE-2083 covers c) above;

b) APP-GW-GEE-2084 covers a), b) and d) above;

c) APP-GW-GEE-2085 covers e) above.

399 **Our assessment concluded that with the implementation of the design changes outlined above, the AP1000 reactor uses BAT to minimise gaseous radioactive waste discharges from the VAS, VHS and VRS**. The potential GDA Issue AP1000-I2 shown in the Consultation Document has been closed out.

400 ONR have included an assessment finding for the licensee to ensure that the design changes associated with the provision of passive HEPA filtration for the nuclear ventilation systems in response to RO-AP1000-43 are completed and that the necessary design and safety documentation is updated accordingly. They have also included an assessment finding for the licensee to establish an appropriate filter change doctrine for all safety important filters within the nuclear ventilation systems.

401 The turbine building ventilation system (VTS) comprises roof exhaust ventilators which help to control the temperature of the building. The turbine building air is not normally contaminated with radioactivity and is exhausted without treatment directly to the air via the turbine building stack. The only potential for contamination of the turbine building air arises if there is a steam generator tube leak, which allows radioactivity from the primary circuit to enter the secondary circuit. In this event, operators will take action to deal with this. (ERs3.3.2.5)

402 Extract air from building equipment in the radwaste building is directed to the main plant vent after passing through HEPA filters. (ERs3.3.2.6)

403 The ventilation air from the ILW store passes through two HEPA filters in series before being discharged through a separate ILW store ventilation stack. (ER3.3.7)

404 **Our assessment concluded that the nuclear ventilation systems on the AP1000 reactor are BAT to minimise the discharge of radioactivity to air.**

7.5 Containment of radioactive liquids in the AP1000

405 Radioactive liquids will be produced in the AP1000, we expect these liquids to be contained within the facility to prevent contamination of land or groundwater (with consequent potential for the production for the production of large volumes of radioactive waste) under normal conditions. Under fault conditions we expect BAT to be used to minimise the probability of contamination occurring and the extent of contamination. (Our REPS (Environment Agency 2010c), RSMDP10 and CLDP1)

406 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.

407 Westinghouse claims that there is no likelihood of direct or indirect discharges of radioactive substances to groundwater. In that case, an AP1000 should not need to be permitted by us for a discharge to groundwater under EPR 10.

408 Westinghouse claims that the AP1000 has '*emphasised best practices with respect to prevention of contamination of land and groundwater*'. Westinghouse describes techniques that should prevent contamination (ERs2.9.5), in particular:

a) simplicity of design reduces lengths of piping and numbers of components reducing potential for leaks;

b) nuclear island is built as a single structure without joints in the concrete and is waterproofed. This prevents leakage from any equipment reaching the environment;

c) use of embedded pipes minimised;

d) use of coolant pumps without mechanical seals;

e) spent fuel pool constructed of ½ inch stainless steel plate joined by full penetration welds. The welds are fitted with leak detection systems. The pool is, as far as possible, within a building so leaks would be contained within the building;

f) all tanks containing radioactive liquid are within buildings that act as bunds preventing any leaks reaching the environment.

409 We confirm that, in principle, such techniques can be BAT. We will need to confirm for specific sites that:

a) the civil engineering design proposed for buildings will achieve the secondary containment claimed for tanks within those buildings;

b) the engineering design of the base of the spent fuel pool or of any tank within buildings should allow for external inspection of the base and walls as far as practicable;

c) the secondary containment shall ensure that any leakage past the primary containment is contained within the building;

d) primary and secondary containments must have independent leak detection and monitoring systems to provide redundancy. Systems for collection/retention of any leakage shall also be provided.

410 We note that ONR have raised a GDA Issue (GI-AP1000-CE-05) concerning secondary containment and leak detection for potential spent fuel pool leaks. The response to that Issue will assist our specific site assessment.

411 In the USA, Regulation 10 CFR 20.1406 requires applicants for licenses to operate nuclear power plant to show how they minimise contamination of the environment. The US NRC issued Regulatory Guide 4.21 in June 2008 to use when reviewing facilities regarding the spread of contamination. Westinghouse claims that AP1000 fully complies with this guidance. The US NRC published review findings in May 2010 and confirmed that the AP1000 '*addressed the minimization of waste generation in 10 CFR 20.1406*' (NRC ADAMS accession number ML0926503740). We accept this guide as an example of good practice and that the NRC finding supports our conclusion below.

412 Westinghouse states that liquid radioactive waste is collected in five tank systems (ER s3.4.2) and provides design and secondary containment information on these tanks (ER Table 3.4-2):

a) reactor coolant drain tank, 3.4 m^3, within containment shell;

b) effluent hold-up tanks, 2 x 106 m^3, secondary containment within auxiliary building;

c) waste hold-up tanks, 2 x 57 m^3, secondary containment within auxiliary building;

d) chemical waste tank, 34 m^3, secondary containment within auxiliary building;

e) monitor tanks, 6 x 57 m^3, secondary containment will be provided to UK regulatory requirements during site-specific design, we have made this an assessment finding, see below.

413 Westinghouse states that the site of an AP1000 should have a network of boreholes for sampling groundwater established during construction. A conceptual site model should be developed for each specific site and this will help location of boreholes. The network will remain in place during operation and be used to monitor groundwater quality and detect any contaminants that inadvertently reach the water table. We expect operators to contact us at the early stages of site-specific designs so that we can advise on the appropriate location and construction of boreholes.

414 **Our assessment concluded that the AP1000 design uses BAT to contain liquids and prevent contamination of groundwater in normal operation. The techniques used should also minimise contamination under fault conditions. However,**

a) **Future operators shall, before the construction phase, provide a BAT assessment to demonstrate that the design and capacity of secondary containment proposed for the monitor tanks is adequate for their location. (AP1000-AF04)**

8 Gaseous radioactive waste disposal and limits

8.1 Conclusions

415 Our conclusion remains unchanged since our consultation.

416 **We conclude that overall the AP1000 utilises the best available techniques (BAT) to minimise discharges of gaseous radioactive waste:**

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

b) **from anticipated operational events.**

417 **We conclude that the gaseous discharges from the AP1000 should not exceed those of comparable power stations across the world. The proposed discharge of carbon-14 in gaseous waste is slightly higher than the range for other European PWRs but this may be accounted for by the increased availability expected of the AP1000.**

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

8.2 Gaseous disposal limits

419 We conclude that any operational, single AP1000 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 AP1000 operator. The limits would also be reviewed periodically thereafter, as data becomes available from operational AP1000 reactors.

Radionuclides or group of radionuclides	Proposed Annual limit (GBq)	Proposed Quarterly notification level (GBq)
Tritium	3000	600
Carbon-14	1000	210
Iodine-131	0.3	0.03
Noble gases excluding argon-41	13000	1300
All other radionuclides (excepting tritium, carbon-14, iodine radionuclides and noble gases)	0.03	0.003

420 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 setting limits 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, 2009a).

421 An individual respondent particularly supported our use of the methodology as it identifies limits to be set based on risk (comment for the UK EPR (GDA126) but the comment was intended for both designs and thus considered relevant to the AP1000).

422 Attendees at our stakeholder seminar queried how limits were set and why they are different for the different designs. We asked Westinghouse 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 '*representative 12-month plant discharge*' 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 matters as uncertainty (an AP1000 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 (up to x2 for a new plant) so that a limit is somewhat above the normally expected value to allow for operational variance and measurement accuracy. Westinghouse applied our methodology (see ERs6.1.2) and provided their '*worst-case plant discharge*' 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.

423 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 Westinghouse and they provided some additional information to justify their claims, however the final decision is ours.

424 Normally, we would use operational experience from a reactor in setting QNLs, but as the AP1000 is not yet operating anywhere in the world, we do not have that information. Therefore, we have used Westinghouse's estimates of monthly discharges 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.

425 A respondent, a future operator (GDA128), was 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.

426 An individual respondent (GDA124) considered some QNLs were 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.

427 An individual respondent suggested that 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 (comment for the UK EPR (GDA126) but the comment was intended for both designs and thus considered relevant to the AP1000).

428 An individual respondent 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 (comment for the UK EPR (GDA126) but the comment was intended for both designs and thus considered relevant to the AP1000 design).

8.3 Gaseous radioactive discharges

429 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.

430 The sources of gaseous discharges are:

a) the reactor coolant system which discharges through the gaseous radioactive waste system;

b) the ventilation systems for the containment building, auxiliary building, turbine building, radwaste building and ILW store; and

c) the secondary circuit condenser air removal system.

431 The release points for gaseous radioactive discharges in normal operation are (ER s3.3.8) the main plant vent which is 5 m higher than the highest building in the vicinity (ER table 3.3-4) and located on the side of the reactor containment building and the ILW store ventilation stack for which design details are not yet available.

432 Radioactivity could be released under abnormal circumstances from the condenser air removal system and the turbine building ventilation system. These releases would be combined and discharged from the turbine building vent which is 38.4 m high (ER table 3.3-5) and located on the turbine building.

433 Westinghouse provides data on the annual amount of radioactivity in gaseous discharges based, which they have calculated using the revised GALE Code (NUREG-0017,US NRC) and modified by proprietary calculations. (ER Tables 3.3-6 to 3.3-8). Westinghouse also proposes disposal limits (ER s6.1 and Table 6.1-7). We have summarised the information in the table below and included information on our proposed limits and QNLs which are explained further below.

Radionuclide or grouping	Westinghouse estimate of representative 12-month plant discharge in months 7 to 18 of the cycle (GBq y^{-1})	Westinghouse estimate of worst-case plant discharge (WCPD) (GBq y^{-1})	Annual limit proposed by Environment Agency (GBq y^{-1})	QNL proposed by Environment Agency (GBq in any 3 calendar months)
Tritium	1,867	3,081	3,000	600
Carbon-14	638	1,053	1,000	210
Argon-41	1,323	2,182	BAT condition applies	
Cobalt-60	0.00322	0.0053	Included in 'other particulate' limit	
Krypton-85	4,070	6,716	Included in noble gas limit	
Strontium-90	0.000444	0.000733	Included in 'other particulate' limit	
Iodine-131	0.207	0.0342	0.3	0.03
Xenon-133	1,335	2,203	Included in noble gas limit	
Caesium-137	0.00133	0.0022	Included in 'other particulate' limit	
Iodine radionuclides	0.595	0.98	Limit on iodine-131	
Noble gases	8,099	13,363	13,000	1,300
Other particulates(1)	0.0122	0.0201	0.03	0.003

(1) Other particulates are particulate radionuclides not individually listed which are present at very low individual activity levels.

434 Westinghouse considered the requirements of the EU Commission Recommendation 2004/2/Euratom to justify the basis for reporting gaseous radioactive waste discharges.

435 Our Radioactive Substances Regulation Environmental Principle RSMDP8 deals with the segregation of wastes and requires that best available techniques should be used to prevent mixing radioactive substances with other materials, including other radioactive substances, where mixing might compromise subsequent effective management or increase environmental impacts or risks.

436 We consider that the AP1000 design provides for segregating waste so that

subsequent management is not compromised.

437 **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 Westinghouse relating to the sources of gaseous radioactive waste is comprehensive, justified and reasonable at the GDA stage.**

8.3.1 Tritium

438 Tritium is present in the coolant usually replacing one or more hydrogen atoms in water (tritiated water) or less prevalent as a dissolved gas. The majority of tritium will remain in liquid effluent after letdown of coolant to the chemical and volume control system (CVS) (some 800 m^3 y^{-1}). Gaseous tritium collected in the CVS is sent to the gaseous radwaste system (WGS) and will be discharged to air through the main vent.

439 Westinghouse considers the abatement options to minimise the gaseous discharge of tritium to be (AP1000 BAT Form 1):

a) decay by delay. Westinghouse considers this option to be impractical as the half-life of tritium is 12.3 years;

b) adsorption processes. Westinghouse considers that adsorption cannot be used to separate tritiated and non-tritiated gas;

c) isotopic concentration may be possible but the technology is not well developed and costs of development would be significant and difficult to justify against the impact of unabated discharges;

d) the use of a condenser will not affect discharge of gaseous tritium but may reduce the discharge of tritiated water vapour. The WGS has a condenser to dry gaseous effluent before it enters the delay beds. This has the benefit of reducing tritium discharge to air by minimising the level of tritiated water vapour in the gaseous effluent. The condensate is directed to liquid effluent;

e) cryogenic systems could be used to liquefy tritium but will be expensive and difficult to justify against impact of unabated discharges. In addition they are complex and could give higher occupational radiation exposure, produce increased amounts of waste for disposal during operation and at decommissioning and require long-term storage of the separated tritium which may difficult to contain;

f) optimising plant design, plant availability and operating practices all contribute to minimising tritium production.

440 Westinghouse claims the AP1000 has an improved design and capability to minimise tritium production. Westinghouse claims that no abatement techniques for minimising gaseous tritium discharges are BAT for use on the AP1000. The use of a condenser in the WGS minimises potential for tritiated water discharge to air.

441 Westinghouse provided an options study on techniques for abatement of tritium in gaseous radioactive waste, summarised above. The study is low on detail but, as the impact of tritium discharges on the environment is low, we accept that no abatement for gaseous tritium is BAT for the AP1000 design.

442 We recognise, however, that operational techniques to minimise tritium discharges will be a matter for future operators of the AP1000, and we will continue to seek assurances that hand over between Westinghouse and future operators will address this matter. (See also our chapter 5)

443 Westinghouse predicts that the annual average discharge of tritium over the 18 month cycle from the AP1000 to atmosphere will be 1,800 GBq. (ER Table 3.3-7)

444 Westinghouse proposes a discharge limit for tritium from the AP1000. It has predicted monthly discharges over an 18-month cycle and used data from the 12 months in which the discharges are highest (month 7 – 18) to calculate the representative 12-month plant discharge to be 1,867 GBq. Westinghouse has applied our limit setting methodology (Environment Agency, 2005) to calculate the annual worst-case plant discharge (WCPD), which it has rounded to give its proposed limit. (ERs6.1.3)

445 Westinghouse has proposed an annual limit of 3,000 GBq for tritium discharges. (ER Figure 6.1-3 and ER Table 6.1-7)

446 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 for a 1000 MWe power station (see Annex 4). We conclude that the gaseous discharge of tritium from UK AP1000 at the predicted annual discharge of 1,800 GBq is comparable to other power stations across the world.

447 The Committee on Medical Aspects of Radiation in the Environment (COMARE) (GDA130) 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'*. We discuss the data we used to confirm discharges were comparable to current power stations in Annex 4. We had difficulty that data was very variable and affected by matters such as shutdowns for periods that were not known. Also the data for the AP1000 are based on predictions as no AP1000 is yet running. Therefore attempting comparison to show lower discharges for the AP1000 was not possible. We have indicated throughout this document areas where the AP1000 has been improved and the discharge reductions that are expected.

448 Westinghouse estimates that the radiological impact from the representative 12-month plant discharge of tritium to atmosphere will result in a dose to the local resident family selected to represent exposure pathways associated with atmospheric releases from the AP1000 of 0.086 $\mu Sv\ y^{-1}$. (ER table 5.2-16). The local resident family comprises infants, children and adults who live 100 m from the aerial discharge point. They spend most of their time at home, some of which is spent outdoors. They eat food from local sources and milk from local farms which are 500 m from the aerial discharge point. They eat locally caught fish and shellfish.

449 COMARE (GDA130) 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 Westinghouse and ourselves throughout this document are therefore based on current standard ICRP recommendations. 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.

450 We have independently calculated limits for tritium discharges that we may grant and based on the information provided by Westinghouse for GDA, our proposed disposal limit for tritium by discharge to atmosphere is 3,000 GBq in any rolling 12 calendar months.

451 Based on the information Westinghouse has provided for GDA on the discharges of tritium in the three months where they are expected to be the highest, our proposed quarterly notification level for tritium is 600 GBq.

452 An individual respondent (GDA39) suggested the QNL for tritium be reduced to 500 GBq. We based the QNL on the highest three month discharge at the end of a cycle just before shutdown for refuelling when monthly discharges are nearly two times that at the beginning of a cycle. The lowest three monthly discharge is less than 400 GBq. We noted above that we may consider two levels of QNL, in that case we might set 500 GBq as ‘normal’ and 600 GBq as ‘shutdown’.

8.3.2 Carbon-14

453 The main source of carbon-14 is the activation of oxygen and nitrogen in the reactor coolant. The carbon-14 is mainly present as carbon atoms in dissolved hydrocarbon gases (75-95 per cent), mainly methane (CH_4) and a small fraction as carbon dioxide (CO_2). A portion of the coolant continually passes through the CVS where dissolved gases are removed and directed to the WGS. The WGS does not remove carbon-14 from the gaseous waste steam and it is discharged through the main plant vent. A small portion of carbon-14 will remain in liquid effluent from the CVS, some of which will become solid waste such as filter elements and spent ion exchange resins.

454 Westinghouse provides a review of available gaseous abatement techniques to minimise carbon-14 discharges. Most of the techniques relate to removing CO_2 from gas streams. As most of the carbon-14 is in the form of hydrocarbons a pre-treatment (for example, high temperature catalytic oxidation) is needed to convert the hydrocarbons to CO_2. This would make any option more expensive and complicated. The options reviewed were: (AP1000 BAT Form 2)

a) alkaline slurry scrubber;

b) alkaline packed bed column;

c) double alkali process;

d) gas absorption by wet scrubbing;

e) ethanolamine scrubbing;

f) absorption in a fluorocarbon solvent;

g) physical absorption on an active surface;

h) reaction with magnesium;

i) isotopic concentration and / or separation;

j) cryogenic systems to give liquid CO_2.

455 Westinghouse indicates that there are issues for all the above options such as high cost because no system is a proven technique for PWRs and they would need developing. In addition, systems would become more complex and there would be

increased occupational radiation exposure. There may also be disposal issues relating to the carbon-14 containing waste generated and additional equipment, which would need to be decommissioned at the end of life.

456 Westinghouse claims that no option considered is BAT for use on the AP1000 and proposes direct discharge of carbon-14 without abatement. It recognises, however, that ion exchange systems provided to remove other radionuclides may remove carbon-14 that is present in the form of carbonate and bicarbonate in the coolant. This may reduce the amount of carbon-14 becoming gaseous radioactive waste.

457 We consider that the techniques Westinghouse has considered for abatement of carbon-14 in gaseous radioactive waste from the AP1000 are comprehensive enough and represent current feasible techniques.

458 **Our assessment concluded that the AP1000 design uses BAT to minimise the discharge of gaseous carbon-14.**

459 We included the need for a '*detailed and robust justification of options for carbon-14 abatement*' as an 'other issue' in our Consultation Document. We now consider that such options are longer term and have not carried this forward as an assessment finding for GDA. We will look for future operators to consider this in their periodic BAT reviews.

460 The Institution of Mechanical Engineers (GDA146) said that more information was needed for a BAT assessment on carbon-14 abatement. We conclude that the AP1000 is BAT in this regard at present but, as noted above, this is an area where developing technology needs to be kept under review by future operators.

461 Westinghouse predicts that the annual average discharge of carbon-14 over the 18-month cycle from the AP1000 to atmosphere will be 606 GBq. ER Table 3.3-7.

462 Westinghouse proposes a discharge limit for carbon-14 from the AP1000. It has predicted monthly discharges over an 18-month cycle and used data from the 12 months in which the discharges are highest (month 7 – 18) to calculate the representative 12-month plant discharge to be 638 GBq. Westinghouse has applied our limit setting methodology (Environment Agency, 2005) to calculate the annual worst-case plant discharge (WCPD), which it has rounded to give its proposed limit. (ERs6.1.3)

463 Westinghouse proposes an annual limit of 1,000 GBq for carbon-14 discharges. (ER Figure 6.1-3 and ER Table 6.1-7)

464 We examined historic discharges (where available) from European PWRs operating over the last 10 to 15 years and we consider that the range of discharges to atmosphere of carbon-14 is 40 to 530 GBq per year for a 1000 MWe power station (see Annex 4). The predicted annual average gaseous discharge of carbon-14 from UK AP1000 normalised for power (542 GBq) slightly exceeds this range.

465 Westinghouse estimates that the radiological impact from the representative 12-month plant discharge of carbon-14 to atmosphere will result in a dose to the local resident family of 3.3 μSv y^{-1}. (ER table 5.2-16)

466 An individual respondent (GDA160) said 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.

467 We have independently calculated limits for carbon-14 discharges that we may grant and, based on the information Westinghouse has provided for GDA, our proposed disposal limit for carbon-14 by discharge to atmosphere is 1,000 GBq in any 12 rolling calendar months.

468 COMARE (GDA130) 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.

469 Based on the information Westinghouse provided for GDA, our proposed quarterly notification level for carbon-14 is 210 GBq.

470 A respondent (GDA39) suggested that the QNL for carbon-14 be reduced to 180 GBq. We based the QNL on the highest three month discharge at the end of a cycle just before shutdown for refuelling when monthly discharges approach two times that at the beginning of a cycle. The lowest three monthly discharge is less than 140 GBq. We noted above that we may consider two levels of QNL, in that case we might set 180 GBq as 'normal' and 210 GBq as 'shutdown'.

8.3.3 Noble gases

471 Removing xenon and krypton radionuclides from the coolant is not normally necessary provided fuel defects are within normally anticipated ranges. However, degassing of the coolant is carried out from time to time, in particular during dilutions of the boron content of the coolant, borations and before shutdowns using the vacuum degasifier within the liquid radwaste system (WLS). (ERs3.3.1.1)

472 Gases from degassing enter the gaseous radwaste system (WGS). The WGS is expected to be operated around 100 hours a year. (ERs3.3.1.2)

473 Argon-41 arising from the activation of naturally occurring argon-40 in the air around the reactor 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.

474 Noble gases are inert and, therefore, difficult to remove from gaseous effluent. Westinghouse has provided information on the abatement options for noble gases in the AP1000 (AP1000 BAT Form 8):

a) Carbon delay beds with a 38.6 day delay for xenon and a 2.2 day delay for krypton.

b) Minimise plant shutdowns.

c) Cryogenics to liquefy and separate noble gases.

475 Westinghouse considers that cryogenics would be expensive in capital and running costs, be complex, increase occupational radiation dose and produce waste that is difficult to dispose of. Westinghouse does not consider cryogenic systems BAT for the AP1000, but chooses to rely on carbon beds in the WGS to delay the discharge of noble gases and, therefore, reduce discharged radioactivity through radioactive decay.

476 The WGS is a once-through, ambient temperature, activated carbon delay system comprising (ERs3.3.1.2):

a) the gas cooler, where they are cooled to about 4°C by the chilled water system;

b) the moisture separator, which is a 0.01 m^3 stainless steel receiver, removes condensed water vapour (including condensed tritiated water vapour) from the cooled gaseous radioactivity stream. The moisture separator design pressure is 150 psig and the design temperature is 93°C. The collected water is periodically discharged automatically to the liquid radioactive waste system;

c) an activated carbon-filled guard bed, which protects the delay beds from abnormal moisture carryover or chemical contaminants. It absorbs radioactive iodine with efficiencies of 99 per cent for methyl iodine and 99.9 per cent for elemental iodine. It also provides increased delay time for xenon and krypton and deep bed filtration of particulates entrained in the gas stream. The guard bed is made of stainless steel with a volume of 0.277 m^3 and a design pressure of 100 psig and a design temperature of 66°C;

d) two activated carbon-filled delay beds in series where xenon and krypton are delayed by a dynamic adsorption process. Radioactive decay of the fission gases during the delay period significantly reduces the radioactivity of the gas flow leaving the system. The delay beds are made of carbon steel with a volume of 2.265 m^3 and a design pressure of 100 psig and a design temperature of 66°C.

   i) The minimum calculated holdup times are 38.6 days for xenon and 2.2 days for krypton, which are based upon a continuous input flowrate to the gaseous radioactive waste system of 0.85 $m^3 h^{-1}$. However, the design basis period of operation is the last 45 days of a fuel cycle when the reactor coolant system dilution and subsequent letdown is greatest. The average input flowrate is 0.024 $m^3 h^{-1}$ which results in longer hold up times being achieved.
   Xenon-133 with a maximum half-life of 5.25 days should be decayed to less than 0.5 per cent of the activity entering the WGS. Krypton-85m, krypton-87 and krypton-88 with half-lives of only a few hours will be substantially reduced, but krypton-85 with a half-life of 10.72 years will be unaffected.

   ii) The two delay beds together provide 100 percent of the required system capacity under design basis conditions. During normal operation a single bed provides adequate performance. This provides operational flexibility to permit continued operation of the gaseous radioactive waste system in the event of operational upset in the system that requires isolation of one bed.

e) a radiation monitor before discharge to the ventilation exhaust duct.

477 Westinghouse provided a BAT assessment to justify the sizing of the delay bed (ERs3.3.5.1). The beds have a folded serpentine design so that each has four adsorption legs where the length to diameter ratio maximises delay time. The two beds are in series and each has four adsorption legs. Westinghouse claims that (ER Figure 3.3-3) increasing the total number of legs beyond eight has a limited effect in reducing activity. Westinghouse concludes that providing two beds in series is BAT, our own assessment confirmed that conclusion.

478 **Our assessment concluded that the techniques considered by Westinghouse for the abatement of xenon and krypton radionuclides in gaseous radioactive waste from the AP1000 reactor are BAT.**

479 The Institution of Mechanical Engineers (GDA146), 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.

480 Westinghouse has predicted the annual average discharge of noble gases over the 18-month cycle from the AP1000 to atmosphere set out in the table below (ER Table 3.3-7):

Radionuclide	Activity in gaseous discharge (GBq y^{-1})
Argon-41	1,300
Krypton radionuclides	3,170
Xenon radionuclides	3,577
Total	8,047

481 Westinghouse proposes a discharge limit for noble gases (excluding argon-41) from the AP1000. It has predicted monthly discharges over an 18-month cycle and used data from the 12 months in which the discharges are highest (month 7 – 18) to calculate the representative 12-month plant discharge to be 8099 GBq. Westinghouse has applied our limit setting methodology (Environment Agency, 2005) to calculate the annual worst-case plant discharge (WCPD), which it has rounded to give its proposed limit. (ERs6.1.3)

482 Westinghouse proposes an annual limit of 13,000 GBq for noble gases (excluding argon-41). (ER Figure 6.1-2 and ER Table 6.1-7).

483 COMARE (GDA130) 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

484 Westinghouse say that the AP1000 GDA design basis is using Westinghouse fuel type 17RFA. Westinghouse provide information on fuel integrity: '*Since the implementation of the Westinghouse 17x17 RFA in 1998 the overall leakage rate of this design, incorporating all the Westinghouse debris protection features, is 0. The overall leakage rate, on a rod basis, of the basic RFA fuel product including designs that do not use all the debris protection features is less than 10^{-5}*' (less than 10^{-5} means less than 10 in a million or 1 in 100,000) (ERs3.2.4)

485 The Health Protection Agency (GDA89) was concerned on the lack of fuel pin integrity data and a case for 18 month refuelling cycles. As noted above Westinghouse use a design basis for fission product discharge from fuel pins as '*that small cladding defects are present in fuel rods producing 0.25 per cent of the core power output*' (AP1000 European Design Control Document). However Westinghouse state in their Environment Report that the '*fuel leak rate is much less*

than the design basis'. The final choice of fuel and refuelling cycle length will be for the future operators. As noted in our paragraph above future operators will need to demonstrate to us that they have used BAT to source the supply of best available fuel (that with the lowest failure rate) and set the length of refuelling cycles used.

486 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and we consider that the range of discharges to atmosphere of noble gases is 100 to 10,000 GBq per year for a 1000 MWe power station (see Annex 4). The predicted annual average gaseous discharge of noble gases from AP1000 at 8047 GBq is within this range. We conclude that gaseous discharge of noble gases is comparable to other power stations across the world.

487 Westinghouse estimates that the radiological impact from the representative 12-month plant discharge disposal to atmosphere will result in doses to the local resident family set out below: (ER table 5.2-16)

a) estimated dose from argon-41 is 0.029 μSv y^{-1}

b) estimated dose from krypton-85 is 0.00137 μSv y^{-1}

c) estimated dose from xenon-133 is 0.00064 μSv y^{-1}

488 We have independently calculated limits on noble gas discharges that we may grant and based on the information Westinghouse provided for GDA, our proposed disposal limit for the disposal of noble gases (excluding argon-41) by discharge to the atmosphere is 13,000 GB in any rolling 12 calendar months.

489 The annual average discharge includes an allowance for failed fuel pins. Westinghouse has not provided an estimate of discharge without pin failures and we normally base our QNL on this level. Our assessment of data suggests that noble gas discharges are often low or at detection levels with no failed pins but increase rapidly with pin failures. To give us early indication of pin failures, we will set the QNL at 1,300 GBq, which is 10 per cent of the disposal limit.

8.3.4 Iodine radionuclides

490 Iodine radionuclides are formed by fission in the fuel and can escape into the coolant through cladding defects. Escape through defects can be accentuated by changes in reactor condition such as power output, in particular at shut-down.

491 As is the case for noble gases, gaseous effluent containing iodine radionuclides is sent to the WGS from the degasifier. Westinghouse claims that iodine radionuclides will be delayed by the carbon delay beds in the WGS, however they do not provide an estimate of reduction in discharges as a result of delay.

492 Iodine radionuclides can also enter the containment atmosphere through leaks of coolant. In such an event Westinghouse claims that most of the iodine radionuclides are deposited on surfaces in the containment area by natural processes. Whenever the containment is ventilated the exhaust air is passed through HEPA filters and impregnated charcoal filters.

493 Westinghouse provides a review of available gaseous abatement techniques to minimise discharge of iodine radionuclides (AP1000 BAT Form 5). These include using:

a) silver reactor technology using solid absorber coated with silver nitrate which retains iodine radionuclides and allows them to decay;

b) mercurex process which is a liquid scrubbing process using mercuric nitrate / nitric acid solution;

c) iodox which is a liquid scrubbing process using hyperazeotropic nitric acid;

d) electrolytic scrubbing which employs an electrolytically generated chemical oxidant;

e) liquid scrubbing with various organic liquids;

f) solid absorption by organic resins;

g) caustic liquid scrubbing using sodium or potassium hydroxide;

h) iodine trapping using silver containing sorbents such as treated zeolites.

494 Westinghouse indicates issues with technical development, complexity or cost for all the above techniques. Westinghouse claims that deposition in the containment and using delay beds are BAT for minimising the discharge of iodine radionuclides to atmosphere from the AP1000.

495 We consider that the techniques Westinghouse has considered for the abatement of iodine radionuclides in gaseous radioactive waste from the AP1000 are comprehensive enough and represent a range of feasible proven techniques from which to assess BAT.

496 **Our assessment concluded that Westinghouse has demonstrated that BAT is used to minimise discharges of iodine radionuclides from the AP1000 reactor.**

497 Westinghouse predicts that the annual average discharge of iodine radionuclides over the 18 month cycle from the AP1000 to atmosphere will be: (ER Table 3.3-6)

a) Iodine-131 = 0.21 GBq

b) Iodine-133 = 0.35 GBq

c) Total iodine radionuclides = 0.56 GBq.

498 Westinghouse proposes a discharge limit for iodine radionuclides from the AP1000. It has predicted monthly discharges over an 18-month cycle and used data from the 12 months in which the discharges are highest (month 7 – 18) to calculate the representative 12-month plant discharge to be 0.595 GBq. Westinghouse has applied our limit setting methodology (Environment Agency, 2005) to calculate the annual worst-case plant discharge (WCPD), which it has rounded to give its proposed limit. (ERs6.1.3)

499 Westinghouse proposes an annual limit of 1 GBq for discharges of total iodine radionuclides. (ER Figure 6.1-1 and ER Table 6.1-7)

500 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and we consider that the range of discharges to atmosphere of iodine-131 is less than 1 to 2000 MBq per year for a 1000 MWe power station (see Annex 4). The predicted annual gaseous discharge of iodine-131 normalised for power is 185 MBq which is within the range. We conclude that gaseous discharge of iodine radionuclides is comparable to other power stations across the world.

501 Westinghouse estimates that the radiological impact from the representative 12-month plant discharge of iodine radionuclides to atmosphere will result in a dose to the local resident family of 0.13 μSv y^{-1} (ER table 5.2-16).

502 We have independently calculated limits on discharges of iodine radionuclides that we may grant and based on the information provided by Westinghouse for GDA. We consider that a limit on iodine-131 is appropriate and our proposed disposal limit for iodine-131 by discharge to the atmosphere is 0.3 GBq in any 12 rolling calendar months.

503 The annual average discharge includes allowance for a failed fuel pin fraction.

Westinghouse has not provided an estimate of discharge without pin failures and we normally base our QNL on this level. Our assessment of data suggests that gaseous iodine radionuclide discharges are often low or at detection levels with no failed pins but increase rapidly with pin failures. To give us early indication of fuel failures, we will set the QNL for iodine-131 at 0.03 GBq, which is 10 per cent of the disposal limit.

8.3.5 Other radionuclides

504 Activated corrosion products are present in the reactor coolant and may be found in aerosols (a dispersion of solid or liquid particles in a gas) produced from:

a) equipment leaks into the containment area. Coolant from these leaks can dry out and the radioactive dust can be re-suspended in air and enter the ventilation systems.

b) treatment of the coolant in the degasifier in the WLS, the gas phase is sent to the WGS.

505 Activated corrosion products can be present as particulate in the final discharge to air. The most significant are particulates containing the radionuclides cobalt-58 and cobalt-60.

506 Fission products may be present in the coolant in the event of fuel cladding failures. The main particulate fission of concern that may be present in gaseous waste discharged to atmosphere is caesium-137.

507 The AP1000 relies on the purification loop in the CVS to control the level of particulates in the coolant and, therefore, minimise radioactivity reaching the WLS or present in leaks. The loop contains mixed bed demineralisers to remove dissolved corrosion products and filters to remove suspended particulate corrosion products.

508 Westinghouse provides a review of abatement techniques to minimise particulates in gaseous discharges (AP1000 BAT Form 9):

a) wet scrubbing;

b) direct discharge;

c) using carbon delay beds in the WGS to provide an effective deep bed filter for removing particulates. Westinghouse claims that HEPA filters are not considered necessary after these beds;

d) use of HEPA filtration in the radiologically controlled area ventilation systems.

509 We consider that the techniques Westinghouse has considered for the abatement of particulates in gaseous radioactive waste from the AP1000 are comprehensive enough and represent feasible techniques to assess BAT.

510 Westinghouse claims that using carbon delay beds as deep bed filters in the gaseous radwaste system and HEPA filtration in the ventilation systems is BAT for minimising the discharge of radioactive particulates in the gaseous waste streams in the AP1000.

511 We assessed ventilation systems for the AP1000 in detail, see chapter 7.4.3, and concluded they were BAT.

512 **Our assessment concluded that the use of carbon delay beds as deep bed filters in the gaseous radwaste system and HEPA filtration in the ventilation systems is BAT for minimising discharges of particulates in gaseous radioactive waste from the AP1000 reactor.**

513 The Health Protection Agency (GDA89) emphasised the importance of applying filtration to all potential particulate discharges, in particular with regard to the GDA Issue AP1000-I2 that was in our Consultation Document. We noted in the previous chapter, that design changes have been approved by Westinghouse and we are now content that the AP1000 has appropriate filtration once the design changes are implemented, AP1000-I2 has been closed out. ONR have an assessment finding for the future licensee to ensure the design changes are implemented.

514 Westinghouse has predicted that the annual average discharge of radioactive particulates from the AP1000 to atmosphere will be (ER Table 3.3-8):

Radionuclide	Expected annual release, MBq
Cobalt-58	8.5
Cobalt-60	3.2
Caesium-137	1.3
Strontium-90	0.44

515 Westinghouse proposes a discharge limit for radioactive particulates from the AP1000. It has predicted monthly discharges over an 18-month cycle and used data from the 12 months in which the discharges are highest (month 7 – 18) to calculate the representative 12-month plant discharge to be 28.4 MBq. Westinghouse has applied our limit setting methodology (Environment Agency 2005) to calculate the worst-case annual plant discharge (WCPD), which it has rounded to give its proposed limit. (ERs6.1.3)

516 Westinghouse proposes an annual limit of 30 MBq for discharges of radioactive particulates. (ER Figure 6.1-7 and ER Table 6.1-7)

517 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and we consider that the range of discharges to atmosphere of fission and activation products is less than 1 to 1000 MBq per year for a 1000 MWe power station (see Annex 4). The predicted annual average gaseous discharge of radioactive particulates from the AP1000 is within this range. We conclude that gaseous discharge of radioactive particulates is comparable to other power stations across the world.

518 Westinghouse estimates that the radiological impact from the representative 12-month discharge of cobalt-60 to atmosphere will result in a dose to the local resident family of 0.00028 µSv y^{-1}. (ER table 5.2-16).

519 Westinghouse estimates that the radiological impact from representative 12-month discharge of caesium-137 to atmosphere will result in a dose to the local resident family of 0.00013 µSv y^{-1}.

520 Westinghouse estimates that the radiological impact from the representative 12-month discharge of strontium-90 to atmosphere will result in a dose to the local resident family of 0.000045 µSv y^{-1}.

521 We have independently calculated limits on radioactive particulates discharges that we may grant and, based on the information Westinghouse has provided for GDA, our proposed limit for the disposal of radioactive particulates by discharge to the atmosphere is 30 MBq in any 12 rolling calendar months.

522 Based on the information Westinghouse has provided for GDA, our proposed

quarterly notification level for total radioactive particulates is 3 MBq.

523 An individual respondent (GDA120) 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 section 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[6]. 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 The only release points for gaseous radioactive discharges in normal operation are (ERs3.3.8):

a) the main plant vent which is 5 m higher than the highest building in the vicinity and located on the side of the reactor containment building. Westinghouse have approved a design change proposal (APP-GW-GEE-1942) to increase the height of the nuclear ventilation plant stack to 5 m above the highest building in the vicinity, the shield building (including a grating that extends on top of that building);

b) ILW store ventilation stack for which the design details are not yet available.

525 Radioactivity could be released under abnormal circumstances from:

a) the condenser air removal system;

b) the turbine building ventilation system.

526 These releases are combined and discharged from the turbine building vent which is 38.4 m high and located on the turbine building.

527 We are satisfied that all gaseous radioactive wastes from the AP1000 are collected into the main plant and turbine building vents for discharge. The vents will be fitted with continuous monitoring equipment to measure radioactive materials entering the air.

528 Westinghouse has assumed an 'effective' stack height of 40 m for GDA (ERs5.2.3.2). 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 heights noted above. Dose assessment for the generic site gives an annual dose of 5.6 μSv for gaseous discharges at limit values. The

[6] 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.

doses are low enough that we accept that the (GDA) vent heights are BAT to reduce impact to a minimum. The future operator for each specific site will need to demonstrate by modelling that the vent heights proposed will be BAT for adequate dispersion allowing for topography (the surface features of the local land area surrounding the site).

529 At the time of our Consultation Westinghouse had assessed doses based upon a lower stack height (22.5 m). Since then Westinghouse have approved a design change proposal to increase the stack height and have updated their dose assessment. An increased discharge height gives better dispersion and a lower dose impact.

530 An individual respondent (GDA85) asked if abnormal releases could be vented from a higher point. The heights of vents are site-specific and depend on balancing effects of buildings and the surrounding area as well as planning considerations. We will ensure vent heights are BAT for the specific locations at the permitting stage.

531 West Somerset Council and Sedgemoor District Council (GDA154) 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

532 Our conclusions have been updated since our consultation. Many respondents were concerned about compliance with the UK's obligations under OSPAR. Our concern under this topic is to ensure that BAT are used to minimise aqueous radioactive waste discharges. We undertook more assessment in regard to this topic, a summary is provided in section 9.5 below. We were unable to complete our assessment as the AP1000 design does not include treatment options for certain aqueous wastes that are incompatible with the design standard of filtration and ion exchange. The AP1000 design includes space and facilities for operators to bring in mobile systems to treat small volume and infrequently produced aqueous wastes such as chemical and detergent wastes that are incompatible with the normal treatment options. We had already identified this gap and include an assessment finding (AP1000-AF05) below. It will be for future operators to show on a site-specific basis that their proposals for aqueous radioactive waste management are BAT to minimise their discharges to the sea. An assessment finding on carbon-14 was identified and is shown below. Our conclusions now reflect that the AP1000 design does not include treatment techniques for aqueous radioactive wastes that are incompatible with filtration and ion exchange.

533 **We conclude that the AP1000 utilises the best available techniques (BAT) to minimise most discharges of aqueous radioactive waste:**

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

b) **from anticipated operational events.**

534 **We conclude that, for aqueous wastes that are incompatible with filtration and ion exchange, the AP1000 has no suitable treatment technique. We have left the treatment of these wastes as a matter for future operators to determine, see our assessment finding below.**

535 **We conclude that the aqueous radioactive discharges from the AP1000 should not exceed those of comparable power stations across the world.**

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

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

a) Future operators shall, at the detailed design phase, provide an assessment to demonstrate that techniques to minimise the discharge of all aqueous radioactive wastes are BAT for their location. In particular, the omission of an evaporator will need to be justified. (AP1000-AF05)

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. (AP1000-AF06)

9.2 Aqueous waste disposal limits

538 We conclude that any operational, single AP1000 unit should comply with the limits and levels set out below for the disposal of aqueous radioactive waste (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 AP1000 operator. The limits would also be reviewed periodically thereafter, as data becomes available from operational AP1000 reactors.

Radionuclides or group of radionuclides	Proposed Annual limit (GBq)	Proposed Quarterly notification level (GBq)
Tritium	60,000	11,000
Carbon-14	7	2.5
Cobalt-60	0.5	0.18
Caesium-137	0.05	0.018
All other radionuclides (excepting tritium, carbon-14, cobalt-60 and caesium137)	5	1.8

539 We have provided information about limit setting and QNLs in chapter 8.2 of this document. Some respondents had comments about this topic and we have dealt with all of these in section 9.3 as they were not specific to gaseous or aqueous limits or QNLs.

540 One individual respondent (GDA14) hoped that '*limits are not so tight as to imperil operation due to random oddities with little dose significance during normal operation*'. Our limits include contingency margins in accordance with our limit setting methodology to avoid any breach of limits due to normal operational variance.

541 An individual respondent (GDA120) 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.

542 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 radioactive waste and to minimise the impact of those discharges on the environment.

543 Westinghouse has provided information on the sources of aqueous radioactive waste (ER s3.4.1) and expected effluent arisings. (ER Table 3.4-1)

544 Reactor coolant system (RCS) effluents arise from two sources:

a) leaks and drainage from primary systems collected in the reactor coolant drain tank of 3.4 m^3;

b) letdown from the chemical and volume control system (CVS) usually as a result of coolant system heat up, boron concentration changes or RCS level reduction for refuelling.

545 These sources are directed to the degasification sub-system in the liquid radwaste system (WLS).

546 **Floor drains** and other waste with potentially high suspended solids contents are routed to one of two waste hold-up tanks. Each of these tanks has a usable volume of 57 m^3 and is normally discharged to the filtration and ion exchange system of the WLS.

547 **Detergent wastes** from the plant hot sinks and showers and some cleanup processes are routed to the chemical waste tank. The chemical waste tank has a volume of 34 m^3. If the radioactivity of this waste is low, the tank contents can be sent to the monitoring tanks for discharge without treatment. If the waste is above an acceptable level for direct discharge, it can be sent to a waste hold-up tank for treatment in the WLS. However, some waste is chemically incompatible with the resins in the WLS and could cause damage. This waste would be treated using mobile treatment plant or by sending the liquids off-site for treatment and disposal (ER3.4.3.9). On a normal basis detergent wastes will be non-ionic cleaning agents.

548 **Chemical waste** collected from laboratories and other small sources is also routed to the chemical waste tank and treated along with detergent waste. (ER3.4.3.10)

549 **Steam generator blowdown** is normally non-radioactive and discharged through a separate blowdown system. If there are steam generator tube leaks, the blowdown could contain radioactivity and, in this event, it is routed to a waste hold-up tank before treatment in the WLS.

550 The WLS is designed to control, collect, process, handle, store and dispose of aqueous radioactive waste generated as a result of normal operations of the AP1000. (ERs3.4 and 3.4.3, a schematic of the system is at ER Figure 3.4-1, repeated as Figure 9.1 below).

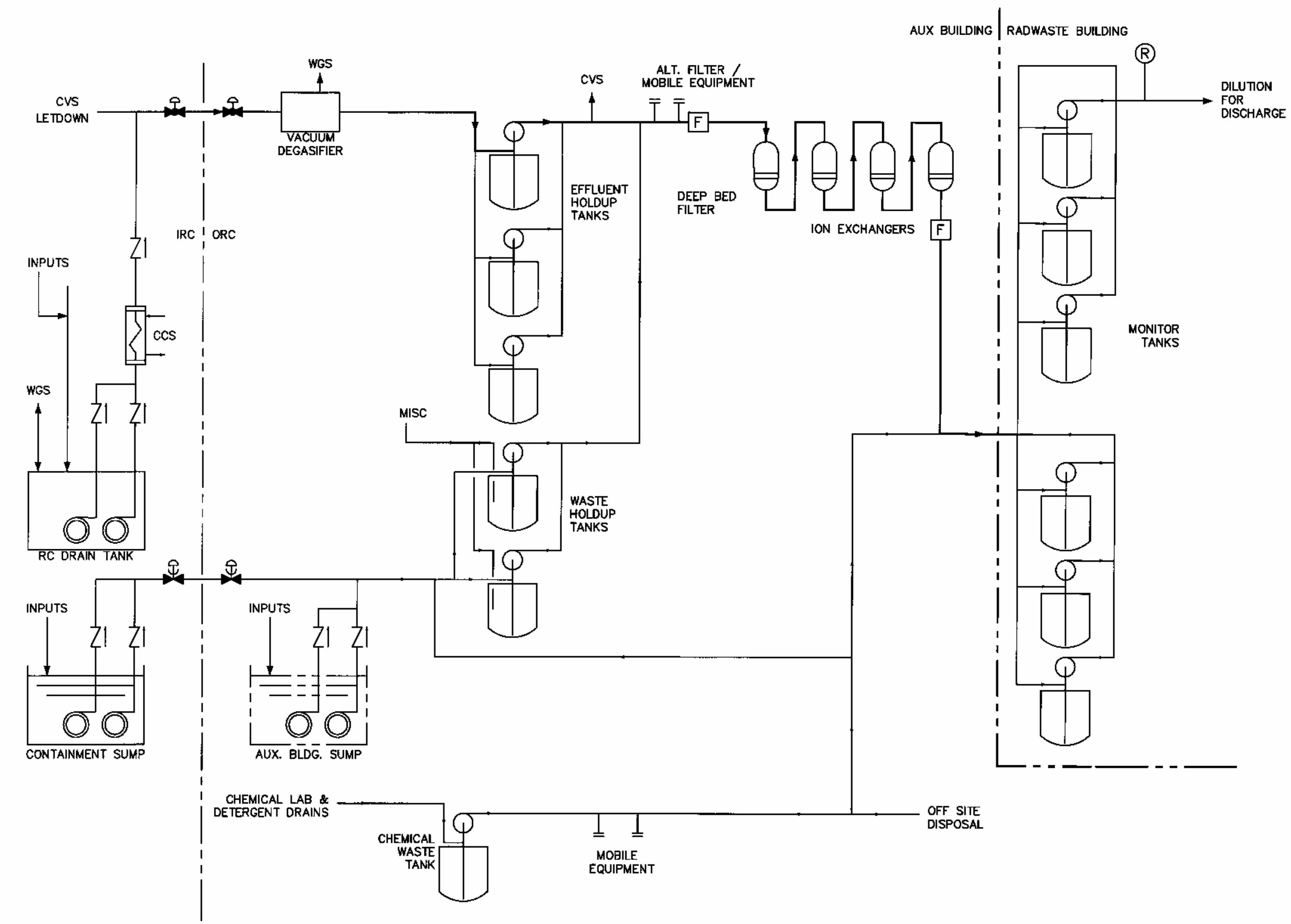


Figure 9.1: AP1000 liquid radwaste system (ER Fig 3.4-1)

551 The WLS is located in the nuclear island auxiliary building and includes a number of waste treatment techniques:

a) **Degasification** - Reactor coolant system effluent entering the reactor coolant drain tank is potentially at high temperature. The design provides for recirculation through a heat exchanger for cooling. The cooled reactor coolant system effluents then pass to a vacuum degasifier to remove hydrogen and dissolved radioactive gases before storage in the two effluent hold-up tanks. The stripped gases are vented to the gaseous radioactive waste system. (ERs3.4.3.1) The degasifier column is designed to reduce hydrogen by a factor of 40, assuming inlet flow of 22.7 m^3 h^{-1} at 54°C. The effluent hold up tanks each have a usable volume of 106 m^3. The contents of the effluent hold-up tanks can be:

   i) returned to the RCS through the CVS;

   ii) passed through the filtration and ion exchange units of the WLS before being sent to the monitor tanks for discharge.

b) **Pre-filtration** - The contents of the effluent hold-up tanks and waste hold-up tanks are normally passed through a treatment system comprising an upstream filter followed by four ion exchange resin vessels in series and a downstream filter. A pre-filter is provided to collect particulate matter in the effluent stream before ion exchange. The unit is constructed of stainless steel and uses disposable filter bags. The pre-filter has a nominal particulate removal efficiency of 90 per cent for 25 µm particles. (ER3.3.3.2)

c) **Deep bed filtration** - The deep bed filter is a stainless steel vessel containing a layered bed of activated charcoal above a zeolite resin. The activated charcoal provides an adsorption media for removal of trace organics and provides protection for the ion exchange resins from contamination with oil from floor drain waste. The activated charcoal collects particulates and, being less dense than the zeolite, can be removed without disturbing the underlying zeolite bed which minimises solid-waste production. The zeolite resin is clinoptilolite zeolite that is provided for caesium removal. Westinghouse claims that deep bed filtration has a decontamination factor of 1 for iodines, 100 for caesium / rubidium (Cs/Rb) and 1 for other radionuclides. (ERs3.4.3.3)

d) **Ion exchange** - The design provides three ion exchange beds after the deep bed filter. The ion exchange vessels are vertical, cylindrical pressure vessels made of stainless steel. They have inlet and outlet process nozzles plus connections for resin addition, sluicing, and draining. The process outlet and flush water outlet connections are equipped with resin retention screens designed to minimise pressure drop. The design flow through the vessels is 17 m^3 h^{-1}. Westinghouse claims that this capacity provides an adequate margin for processing a surge in the generation rate of this waste. At the operational stage the ion exchange media will be selected by the plant operator to optimise system performance according to prevailing plant conditions. Typically the resin beds will use the following resins:

   i) the first bed will contain a cation exchange resin and Westinghouse claims that this resin will have a decontamination factor of 1 for iodine, 10 for Cs/Rb and 10 for other radionuclides;

   ii) the second bed will contain a mixed bed resin and Westinghouse claim a decontamination factor of 100 for iodine, 2 for Cs/Rb and 100 for other radionuclides;

   iii) the third bed will contain a mixed bed resin and Westinghouse claim a decontamination factor of 10 for iodine, 10 for Cs/Rb and 10 for other radionuclides.

   The ion exchange vessels can be manually bypassed and the order of the last two can be interchanged to ensure that the ion exchange resin is used completely.

The ion exchange beds operate in the borated saturated mode. This means that the boric acid present in the reactor coolant effluent is not removed by the ion exchange beds. (ERs3.4.3.4).

e) **After filter -** This filter is provided downstream of the ion exchangers to collect particulate matter, such as resin fines. The unit is constructed of stainless steel and uses disposable filter cartridges. The design filtration efficiency is 98 per cent removal of 0.5 μm particles. (ERs3.4.3.5)

552 The WLS is designed to be flexible and capable of handling a relatively wide range of inputs, including both high grade water (from reactor effluents) and low grade water (floor drains). The flexible design is claimed to allow the operator to make an evaluation to determine the optimum processing technique.

553 To help this evaluation, each collection tank (effluent hold-up tank, waste hold-up tank) will typically be mixed and sampled before processing. The sample will be analysed to provide information on the chemistry and radiological content of the tank contents.

554 It is anticipated that all ion exchangers and filters will be in service and routine bypass of the ion exchangers is not anticipated. However, there may be circumstances where it may be acceptable. The selection of ion exchange vessels in and out of service is made through alignment of manually operated valves. These valves are opened and closed by an operator and are under administrative control to prevent an inadvertent bypass of demineralisers or sub-optimal treatment of waste.

555 Westinghouse claims that the liquid radioactive waste system is designed to handle most liquid effluents and other anticipated events using installed equipment. However, for infrequent events or for effluent that is not compatible with the installed equipment, temporary equipment may be brought into the radioactive waste building mobile treatment facility truck bays. Any treatment of liquid waste by mobile or temporary equipment will be controlled and confirmed by plant procedures.

556 Mobile equipment connections are provided to and from various locations in the liquid radioactive waste system to allow mobile equipment to be used alongside or instead of installed equipment. Treated liquids would be returned to the liquid radioactive waste system or removed from the site for disposal elsewhere. (ERs3.4.3.8)

557 We are not satisfied that BAT has been demonstrated for minimising discharges of all aqueous radioactive wastes. We accept that the AP1000 design allows for additional techniques to be installed and do not consider this a fundamental GDA Issue. However, future operators will need to demonstrate to us that BAT for their location is used to minimise discharges of aqueous radioactive wastes. In particular the provision of evaporation may be a BAT requirement (see section 9.5 on OSPAR).

558 **Our assessment concluded that BAT has not been demonstrated for minimising discharges of all aqueous radioactive wastes. However, for those aqueous wastes compatible with treatment by filtration and ion exchange we accept that the AP1000 utilises BAT.**

a) Assessment finding: Future operators shall, at the detailed design phase, provide an assessment to demonstrate that techniques to minimise the discharge of all aqueous radioactive wastes are BAT for their location. In particular, the omission of an evaporator will need to be justified. (AP1000-AF05)

559 Westinghouse has provided a BAT case for the WLS that supports using ion exchange and a cartridge filter. Two alternatives are discussed below. (ERs3.4.4)

560 An individual respondent (GDA39) asked if '*conventional effluent treatment plant were used to control pH, dissolved solids etc*'. The AP1000 uses conventional techniques to control pH (the addition of acid or caustic as required to neutralise waste). The ion exchange resins mentioned above remove radioactive materials (such as cobalt-60)

dissolved in the waste and we consider represent BAT for nuclear plant rather than conventional effluent treatment using precipitation.

9.2.1 Evaporation in place of ion exchange

561 Westinghouse recognises that effluents could be treated by evaporation. (ER Figure 3.4-2). The evaporator bottoms would need to be treated to create a solid waste for disposal. The distillate could be discharged to water after treatment and polishing with demineralisers and filters but would still contain radioactivity. Westinghouse has compared using evaporators against ion exchange in ER Table 3.4-5.

562 Westinghouse claims that reactors located on rivers tend to use evaporators to minimise radioactive liquid discharges as rivers have less capacity for dilution and dispersal of effluents. The AP1000 GDA case is for discharge of aqueous radioactive waste to sea where dispersal is less of an issue.

563 Westinghouse claims that evaporators tend to be complex and need significant maintenance, with associated occupational radiation exposure of workers. There is also the cost of steam supply to run the evaporators, which diverts steam away from generating electricity.

564 Westinghouse estimates that 102 m^3 of evaporator bottoms would need to be disposed of each year. (ER Table 3.4-5) The treatment and disposal of the evaporator bottoms concentrate would have an impact in terms of radiation exposure to workers and costs.

565 Westinghouse claims that using ion exchange and filters offers a simpler and safer option that will still effectively control discharges of radioactivity. Westinghouse believes its impact assessment for the GDA generic site demonstrates that discharges are not excessive. It concludes that the proposed WLS is BAT. (ERs3.4.4.1)

566 We accept that the evaporation of all aqueous waste may not be BAT when the treatment and disposal of the evaporator bottoms is considered within an assessment. However, Westinghouse state that some aqueous wastes will not be compatible with ion exchange treatment. They allow for mobile equipment to be brought into the AP1000 to treat this. We said above that this does not demonstrate BAT for minimising the discharge of all aqueous wastes. We have left the treatment of wastes incompatible with the filtration and ion exchange system outside GDA and put an assessment finding on future operators to demonstrate BAT for the treatment options they intend to install at their sites. We consider the use of an evaporator is an option that must be considered. The future operator will need to show that aqueous waste treatment techniques have been optimised to minimise the dose to members of the public to comply with the UK commitments under OSPAR (see section 9.5).

9.2.2 Filtration options

567 The WLS includes a final 0.5 µm disposable cartridge filter to remove particulate material greater than 0.5 µm in size. Westinghouse has considered other filter technologies that potentially could remove smaller particulate material at sizes from 0.1 to 0.001 µm. These are:

a) microfiltration;

b) ultrafiltration;

568 Westinghouse claims that these techniques have disadvantages that outweigh the benefit of reduced particulates because:

a) high pressure systems are needed which may increase the risk of leaks;

b) system designs are more complicated;

c) membranes used in the system may be subject to degradation by radioactivity;

d) higher maintenance requirements may lead to potential for higher occupational radiation exposure;

e) more equipment may be produced which needs to be disposed of as radioactive waste at decommissioning;

f) higher capital and operating costs.

569 Westinghouse concludes that using cartridge filters is BAT for final liquid filtration in the AP1000. (ERs3.4.4.4)

570 **Our assessment concluded that the use of 0.5 µm disposable cartridge filters is BAT for the AP1000 at this time. Future operators will need to keep other filter technologies under review when they update their BAT assessments.**

9.3 Aqueous radioactive discharges

571 Westinghouse provides data on the annual amount of radioactivity in aqueous discharges that it has calculated using the revised GALE Code (NUREG-0017) and modified by proprietary calculations (ER table 3.4-6). Westinghouse also proposes disposal limits (ER s6.1 and Table 6.1-8). We have summarised the information below in and included information on our proposed limits and QNLs which are explained further below.

	Representative 12-month plant discharge in months 7 to 18 of the cycle (GBq y^{-1})	Westinghouse estimate of worst-case plant discharge (WCPD) (GBq y^{-1})	Annual limit proposed by Environment Agency (GBq y^{-1})	QNL proposed by Environment Agency (GBq in any 3 calendar months)
Tritium	35,090	57,900	60,000	11,000
Carbon-14	4.42	7.30	7	2.5
Cobalt-60	0.301	0.497	0.5	0.18
Caesium-137	0.03	0.0497	0.05	0.018
Other radionuclides (excepting tritium, carbon-14, cobalt-60 and caesium-137) taken together	2.95	5.35	5	1.8

572 Westinghouse has considered the requirements of the EU Commission Recommendation 2004/2/Euratom to justify the basis for reporting aqueous radioactive waste discharges.

573 Our Radioactive Substances Regulation Environmental Principle RSMDP8 deals with the segregation of waste and requires that best available techniques should be used to prevent mixing radioactive substances with other materials, including other radioactive

substances, where mixing might compromise subsequent effective management or increase environmental impacts or risks. We conclude that the AP1000 design provides for segregating aqueous wastes so that subsequent management is not compromised.

574 **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 Westinghouse has provided relating to the sources of aqueous radioactive waste is comprehensive, justified and reasonable at the GDA stage.**

9.3.1 Tritium

575 Tritium is present as tritiated water in the reactor coolant. Coolant is processed in the CVS and Westinghouse states that approximately 800 m^3 each year will be sent to the WLS for discharge to sea after processing.

576 The filtration and ion exchange systems in the WLS do not effectively remove tritium. Westinghouse reviewed abatement techniques to determine techniques that represent BAT for tritium in aqueous radioactive waste from the AP1000 (AP1000 BAT Form 1):

a) adsorption - Westinghouse claims this has no known application for tritium;

b) wet scrubbing – Westinghouse claims this is only applicable to particulate in air and not tritiated water;

c) evaporation – Westinghouse claims there is no benefit in evaporation as tritiated water behaves as water and no separation is achieved;

d) precipitation / filtration – Westinghouse claims this is not applicable for tritiated water;

e) ion exchange – Westinghouse claims this is not applicable for tritiated water;

f) isotopic concentration / separation – Westinghouse recognises this is a possible technique for abating tritium but the technology is as yet undeveloped and the costs to develop the technology and apply it to the AP1000 would be significant and difficult to justify against the impact of unabated discharges;

g) decay by delay – Westinghouse claims this is impractical as the half-life of tritium is 12.3 years.

577 Westinghouse claims that, in relation to tritium discharges to sea, direct discharge is BAT. Westinghouse also claims that plant operation can significantly affect the amount of tritium produced and that the AP1000 design that optimises plant availability contributes to minimising tritium production. Management techniques such as operator training which optimise operations are relevant to reducing the production of tritium.

578 Westinghouse provides only basic details on the techniques for abatement of tritium in aqueous radioactive waste discharges. However we recognise that the impact of tritium in liquid discharges without abatement is low, therefore we accept that, at this time, direct discharge to the sea is BAT for the AP1000.

579 Optimising plant availability to minimise plant shutdowns and tritium production will be a matter for future operators of the AP1000. We will continue to seek assurances that the hand over between Westinghouse and future operators will address this matter.

This is covered in more detail in our section 6.3.

580 Westinghouse predicts that the annual average discharge of tritium from the AP1000 to sea will be 33,400 GBq. (ER Table 3.4-6)

581 Westinghouse proposes a discharge limit for tritium from the AP1000. It has predicted monthly discharges over an 18-month cycle and used data from the 12 months in which the discharges are highest (month 7 – 18) to calculate the representative 12-month plant discharge to be 35,090 GBq. Westinghouse has applied our limit setting methodology (Environment Agency, 2005) to calculate the annual worst-case plant discharge (WCPD), which it has rounded to give its proposed limit. (ERs6.1.3)

582 Westinghouse proposes an annual limit of 60,000 GBq for tritium in aqueous radioactive waste discharges. (ER Figure 6.1-8 and ER Table 6.1-8).

583 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and we consider that the range of discharges to water of tritium is 2000 to 30,000 GBq per year for a 1000 MWe power station (see Annex 4). The predicted annual average aqueous discharge of tritium from AP1000 normalised for power is 29,908 GBq. We conclude that aqueous discharge of tritium is comparable to other power stations across the world.

584 Westinghouse estimates that the radiological impact from the representative 12-month plant discharge of tritium to sea will result in a dose to the local fisherman family, selected to represent the exposure pathways associated with discharges from the AP1000 to the coastal environment, of 0.024 μSv y^{-1}. (ER table 5.2-12). The fisherman and his family are assumed to spend time on intertidal sediments in the area and consume high levels of locally caught fish and shellfish as well as smaller amounts of locally produced fruit and vegetables from local sources up to 500 m from the aerial discharge point. This group live far enough from the site not to be exposed to direct radiation from atmospheric releases.

585 We have independently calculated limits for tritium discharges that we may grant and based on the information Westinghouse provided for GDA, our proposed disposal limit for tritium by discharge to the sea is 60,000 GBq in any 12 rolling calendar months.

586 Some attendees to our stakeholder seminar and '*Stop Hinkley*' (GDA159) expressed concern with the tritium discharge limits and that we give tritium discharge insufficient importance. We said in chapter 7.3.1 that we consider that BAT is used in the AP1000 to minimise the production for tritium at source. The AP1000 will discharge considerably less tritium than the current AGR stations where the limits are 650,000 GBq y^{-1} while generating similar electricity (1117 MWe for the AP1000 against up to 1261 MWe for an AGR). The calculated impact at 0.024 μSv y^{-1} is low and should not be significant.

587 Based on the information Westinghouse provided for GDA, our proposed quarterly notification level for tritium is 11,000 GBq.

9.3.2 Carbon-14

588 Carbon-14 is present in the coolant mainly as dissolved hydrocarbon gases. These gases are mostly removed in the CVS and WLS degasifier and are discharged through the WGS to the air. Westinghouse claims only a small portion of carbon-14 remains in the liquid effluent, although we note ONR have queried how using zinc acetate may increase the amount of carbon-14 remaining as graphite particles in the liquid. Of the total predicted production of 662 GBq y^{-1}, Westinghouse predicts 53 GBq will be in solid waste, 606 GBq will be discharged to air and 3.3 GBq discharged to the sea. (AP1000 BAT Form 2)

589 Westinghouse claims that the nuclear industry does not currently use any specific

techniques to minimise the carbon-14 content of aqueous radioactive waste.

590 Westinghouse has considered the following options for abatement of carbon-14 in aqueous radioactive waste:

a) ion exchange - The AP1000 design provides ion exchange beds as the primary abatement technique for removing trace dissolved metal radionuclides. These beds will also be effective at removing any carbon-14 in the form of carbonates or bicarbonates, which will result in carbon-14 in certain solid waste, mainly in spent resins.

b) evaporation – Westinghouse has considered using evaporation but claim this would have little effect as many forms of carbon-14 would remain with the distillate for disposal to the sea.

c) no abatement – direct discharge of aqueous radioactive waste to the environment.

591 Westinghouse claims, considering the low proportion of carbon-14 remaining in aqueous radioactive waste after the ion exchange beds, that direct discharge is BAT for the AP1000.

592 Our assessment concluded that, at this time, direct discharge to the sea is BAT for the AP1000.

593 We included the need for a 'detailed and robust justification of options for carbon-14 abatement' as an other issue in our Consultation Document. We now consider that other options for carbon-14 abatement are unlikely to be available in the short term and have not carried forward as an assessment finding for GDA. We will look for future operators to consider in their periodic BAT reviews.

594 Westinghouse predicts that the annual average discharge of carbon-14 from the AP1000 to sea will be 3.3 GBq. (ER Table 3.4-6)

595 Westinghouse proposes a discharge limit for carbon-14 from the AP1000. It has predicted monthly discharges over an 18-month cycle and used data from the 12 months in which the discharges are highest (month 7 – 18) to calculate the representative 12-month plant discharge to be 4.42 GBq. Westinghouse has applied our limit setting methodology (Environment Agency, 2005) to calculate the annual worst-case plant discharge (WCPD), which they have rounded to give their proposed limit. (ERs6.1.3)

596 Westinghouse proposes an annual limit of 7 GBq for carbon-14 in aqueous radioactive waste discharges. (ER Figure 6.1-9 and ER Table 6.1-8)

597 We have limited information about carbon-14 discharges from PWRs operating over the last 10 to 15 years but we consider that the range of discharges to water of carbon-14 is 3 to 45 GBq y^{-1} for a 1000 MWe power station (see Annex 4). The predicted annual average aqueous discharge of carbon-14 from AP1000 is 3.3 GBq, well within this range. We conclude that aqueous discharge of carbon-14 from the AP1000 is comparable to other power stations across the world.

598 Westinghouse estimates that the radiological impact from the representative 12-month plant discharge of carbon-14 to sea will result in a dose to the local fisherman family of 1.6 μSv y^{-1}. (ER table 5.2-12)

599 We have independently calculated limits for carbon-14 discharges that we may grant and, based on the information Westinghouse has provided for GDA, our proposed disposal limit for carbon-14 by discharge to the sea is 7 GBq in any 12 rolling calendar months.

600 Based on the information Westinghouse has provided for GDA, our proposed quarterly notification level for carbon-14 is 2.5 GBq.

9.3.3 Iodine radionuclides

601 Iodine radionuclides are formed in the fuel and are only present in the coolant in the event of fuel cladding defects. While it is not their primary function, the mixed bed demineralisers in the CVS purification loop will remove significant amounts of iodine radionuclides (AP1000 BAT Form 5).

602 Westinghouse claims that the only technique that might be used to further reduce iodine radionuclides in aqueous radioactive waste is chemical trapping. This would add appropriate chemicals that trap iodine (for example, hydrazine hydrate) to the spray system or to the reactor sump. Westinghouse claims that chemical trapping is not a developed technique, and costs to develop the technology and apply it to the AP1000 would be significant and difficult to justify against the impact of unabated discharges.

603 Westinghouse has provided little detail on the techniques for abatement of iodine radionuclides in aqueous radioactive waste discharges from the AP1000. However, we recognise that using demineralisers may contribute to reducing the amount of iodine radionuclides in aqueous radioactive waste.

604 ER Table 3.4-6 gives the expected annual release of iodine radionuclides in liquid effluent discharged to the sea as:

a) iodine-131 – 0.015 GBq, half-life 8 days;

b) iodine-132 – 0.020 GBq, half-life 2.3 hours;

c) iodine-133 – 0.029 GBq, half-life 20.8 hours;

d) iodine-134 – 0.006 GBq, half-life 52.6 minutes;

e) iodine-135 – 0.024 GBq, half-life 6.61 hours.

605 The short half-lives of the iodine radionuclides other than iodine-131 mean they rapidly become insignificant and only iodine-131 is usually considered.

606 We have limited information about iodine discharges from PWRs operating over the last 10 to 15 years, but we consider that the range of discharges to water of iodine radionuclides is 0.01 to 0.03 GBq per annum for a 1000 MWe power station (see Annex 4). The predicted aqueous discharge for iodine 131 is 0.015 GBq, which is within this range. We conclude that aqueous discharge of iodine radionuclides from the AP1000 is comparable to other power stations across the world.

607 Westinghouse does not propose an annual disposal limit to sea for iodine radionuclides.

608 Westinghouse has not assessed the impact in terms of dose resulting from the disposal of iodine radionuclides by discharge to the sea. (ER table 5.2-12)

609 We do not consider that a specific limit should be set for iodine radionuclides in aqueous radioactive waste discharges but in permits we may issue we will require that operators demonstrate that BAT is used to minimise the amount of all radionuclides including iodine radionuclides discharged in liquid waste.

9.3.4 Other radionuclides

610 Aqueous radioactive waste can contain other radionuclides as well as those specifically considered above. These include activation products and fission products. Activation products, for example cobalt-58 and cobalt-60, may be formed by neutron activation of materials within the reactor which may be released into the coolant by corrosion processes and may be present dissolved in the coolant or as particulate material. The reactor materials and coolant chemistry are chosen to minimise both the

potential for activation and corrosion. Fission products, for example, caesium-137 may enter the coolant in the event of a fuel pin failure. The coolant is recycled through filters and demineralisers in the purification loop of the CVS to remove suspended and dissolved radioactive materials. However, low concentrations are still found in managed discharges and minor leaks of coolant reaching the WLS.

611 **Strontium-90** is released into the coolant in the event of fuel pin failure. The mixed bed demineraliser and filters in the WLS will remove strontium from aqueous radioactive waste. (AP1000 BAT Form 4)

612 Westinghouse identifies the following abatement techniques for strontium-90 in aqueous radioactive waste:

a) ion exchange;

b) wet scrubbing;

c) no abatement – direct discharge of aqueous radioactive waste to the environment;

d) evaporation;

e) precipitation / filtration;

f) adsorption;

g) isotopic concentration / separation;

h) delay tank– delay tanks could be used to delay discharges to take advantage of radioactive decay.

613 Westinghouse claims that the most effective techniques for abating strontium-90 is ion exchange. The AP1000 design includes ion exchange, although it is recognised that the choice of ion exchange resin in the AP1000 is not specifically aimed at strontium-90 removal but is optimised over a range of radionuclides.

614 Westinghouse provides little detail on the techniques for abatement of strontium-90 in aqueous radioactive waste discharges from the AP1000. We consider the optioneering study does not contain enough detail to identify the best option, however we recognise that ion exchange is likely to be the best option.

615 Westinghouse predicts that the annual average discharge of strontium-90 from the AP1000 to sea will be 0.00025 GBq. (ER Table 3.4-6)

616 Westinghouse calculates a discharge limit for strontium-90 from the AP1000. They have predicted monthly discharges over an 18-month cycle and used data from the 12 months in which the discharges are highest (month 7 – 18) to calculate representative 12-month plant discharge to be 0.000324 GBq. Westinghouse has applied our limit setting methodology (Environment Agency 2005) to calculate the annual worst-case plant discharge (WCPD), which they have rounded to give its calculated limit. (ERs6.1.3)

617 Westinghouse calculates an annual limit of 0.0005 GBq for strontium-90 in liquid discharges. (ER Figure 6.1-3 and ER Table 6.1-6)

618 Westinghouse estimates that the radiological impact from representative 12-month plant discharge of strontium-90 to sea will result in a dose to the local fisherman family of 0.0000015 µSv y^{-1}. (ER table 5.2-12)

619 We do not consider that a specific limit should be set for strontium-90 in aqueous radioactive waste discharges, but in any permit we may issue we will require that operators demonstrate that BAT is used to minimise the amount of all radionuclides, including strontium-90 discharged in liquid waste. Strontium-90 is included in the limit we set for 'all other radionuclides (excepting tritium, carbon-14, cobalt-60 and caesium-137)'.

620 **Caesium-137** is a fission product which may be present in aqueous radioactive waste

as a result of fuel failure or from tramp uranium.

621 Westinghouse considers the following abatement techniques for caesium-137 aqueous radioactive waste (AP1000 BAT Form 6):

a) Demineralisation - zeolite beds and cation resins can remove caesium isotopes. During normal operation the reactor coolant contains lithium hydroxide and the demineraliser in the CVCS used to routinely clean-up reactor coolant on-load can be saturated with lithium ions, making it less effective at removing some radionuclides including caesium-137. A cation resin bed demineraliser located downstream of the mixed bed demineralisers can be used intermittently to control the concentration of lithium-7 (pH control) and caesium concentration in the reactor coolant system.

b) Filtration – filtration can be used for removing insoluble species, but most caesium radionuclides are soluble in water, therefore filtration has limited application for removing caesium.

c) No abatement – direct discharge of aqueous radioactive waste to the environment.

622 Westinghouse claims that demineralisation is BAT for caesium-137. It recognises that demineralisation costs more than direct discharge and will produce secondary waste. But, this is outweighed by reduction in doses to members of the public and environmental impact, bearing in mind that the secondary waste is highly likely to be suitable for disposal as solid waste.

623 Our assessment concluded that Westinghouse has demonstrated that BAT is used to minimise discharges of caesium-137 in aqueous radioactive waste from the AP1000.

624 Westinghouse predicts that the annual average discharge of caesium-137 from the AP1000 to sea will be 0.023 GBq. (ER Table 3.4-6)

625 Westinghouse calculated a discharge limit for caesium-137 from the AP1000. It has predicted monthly discharges over an 18-month cycle and used data from the 12 months in which the discharges are highest (month 7 – 18) to calculate the representative 12-month plant discharge to be 0.0301 GBq. Westinghouse has applied our limit setting methodology (Environment Agency 2005) to calculate the annual worst-case plant discharge (WCPD), which they have rounded to give its calculated limit. (ERs6.1.3)

626 Westinghouse calculated an annual limit of 0.05 GBq for caesium-137 in liquid discharges. (ER Table 6.1-6)

627 Westinghouse estimates that the radiological impact from the representative 12-month plant discharge of caesium-137 to sea will result in a dose to the local fisherman family of 0.0034 $\mu Sv\ y^{-1}$. (ER table 5.2-12)

628 We have independently calculated limits for caesium-137 discharges that we may grant and, based on the information Westinghouse has provided for GDA, our proposed disposal limit for caesium-137 by discharge to the sea is 0.05 GBq in any 12 rolling calendar months.

629 Based on the information Westinghouse has provided for GDA, our proposed quarterly notification level for caesium-137 is 0.018 GBq.

630 **Plutonium-241** can be produced by successive neutron capture of uranium in the AP1000. (AP1000 BAT Form 7)

631 Westinghouse identifies the following abatement options for plutonium-241:

a) Filtration / ion exchange;

b) evaporation;

c) fuel storage pool cooling and clean up system - The fuel storage pool water chemistry can be controlled to minimise fuel-clad corrosion and minimise the release of radioactivity into the pool water;

d) monitoring of discharges delay tank – delay tanks can be used to delay discharges to take advantage of radioactive decay;

e) adsorption;

f) wet scrubbing;

g) no abatement – direct discharge of aqueous radioactive waste to the environment;

h) precipitation.

632 Westinghouse claims that using filtration and ion exchange and using the fuel storage pool cooling and clean up system along with monitoring of discharges is BAT for plutonium-241. Westinghouse claims that in the event of a higher than normal level of plutonium-241 in the aqueous radioactive waste the discharge would be terminated.

633 We do not consider that monitoring of discharges is an abatement technique, however we recognise that filtration / ion exchange and using the fuel storage pool cooling and clean up system will provide abatement for plutonium-241.

634 Westinghouse predicts that the annual average discharge of plutonium-241 from the AP1000 to sea will be 0.00008 GBq. (ER Table 3.4-6)

635 Westinghouse calculates a discharge limit for plutonium-241 from the AP1000. It has predicted monthly discharges over an 18-month cycle and used data from the 12 months in which the discharges are highest (month 7 – 18) to calculate representative 12-month plant discharge to be 0.000108 GBq. Westinghouse has applied our limit setting methodology (Environment Agency, 2005) to calculate the annual worst-case plant discharge (WCPD), which they have rounded to give its calculated limit. (ERs6.1.3)

636 Westinghouse calculates an annual limit of 0.0002 GBq for plutonium-241 in aqueous radioactive waste discharges (ER Table 6.1-6)

637 Westinghouse estimates that the radiological impact from representative 12-month plant discharge of plutonium-241 to sea will result in a dose to the local fisherman family of 0.0000027 μSv y^{-1}. (ER table 5.2-12)

638 We do not consider that a specific limit should be set for plutonium-241 in aqueous radioactive waste discharges, but in any permit we may issue we will require that operators demonstrate that BAT is used to minimise the amount of all radionuclides, including plutonium-241 discharged in aqueous radioactive waste. Plutonium-241 is included in the limit we set for ‘all other radionuclides (excepting tritium, carbon -14, cobalt-60 and caesium-137)’.

639 **Beta emitting particulates** - Westinghouse provides a review of other techniques that are available for removing particulates in liquid such as (AP1000 BAT Form 9):

a) flocculation;

b) particulate separation;

c) evaporation – Westinghouse claims operational experience has shown problems, and that drawbacks outweigh the benefits;

d) precipitation / filtration;

e) using a hydrocyclone;

f) mixed bed demineralisers;

g) ultrasonic fuel cleaning;

h) minimising plant shutdown.

640 Westinghouse claims the most effective option for abating beta emitting particulates in aqueous radioactive waste is to minimise plant shutdowns, because plant shutdowns perturb the corrosion characteristics of the primary circuit and may cause more corrosion products to enter the coolant. This, taken with an increase in the amount of effluent for processing as a result of additional letdown, increases the amount of beta emitting particulates in the aqueous radioactive waste. In addition, the AP1000 design includes mixed bed demineralisers.

641 Westinghouse claims that the other techniques they have considered are not particularly effective and would be costly to implement and are not included in the AP1000 design.

642 We conclude that the techniques Westinghouse has considered for the abatement of fission and activation products in the AP1000 are comprehensive enough and represent feasible techniques at this stage. However, we recognise that techniques may be developed in the future which may be worth considering.

643 Westinghouse predicts that the annual average discharge of the following activation and fission products from the AP1000 to sea will be: (ER Table 3.4-6)

a) iron-55 – 0.49 GBq

b) cobalt-58 – 0.41 GBq

c) cobalt-60 – 0.23 GBq

d) nickel-63 – 0.54 GBq

e) other activation and fission products - 1 GBq.

644 Westinghouse calculates discharge limits for activation and fission products from the AP1000. It has predicted monthly discharges over an 18-month cycle and used data from the 12 months in which the discharges are highest (month 7 – 18) to calculate representative 12-month plant discharge (Table 6.1-6). Westinghouse has applied our limit setting methodology (Environment Agency 2005) to calculate the annual worst-case plant discharge (WCPD), which they have rounded to give its calculated limit. (ERs6.1.3)

645 Westinghouse has calculated annual limits for the following radionuclides in liquid discharges: (ER Figure 6.1-3 and ER Table 6.1-6)

a) iron-55 – 1.0 GBq

b) cobalt-58 – 0.9 GBq

c) cobalt-60 – 0.5 GBq

d) nickel-63 – 1.0 GBq

e) other activation and fission products - 2 GBq.

646 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and we consider that the range of discharges to water of fission and activation products is of less than 1 to 15 GBq per year for a 1000 MWe power station (see Annex 4). The predicted annual average aqueous discharge of fission and activation products from the AP1000 is 2.67 GBq and within this range. We conclude that the aqueous discharge of fission and activation products from the UK AP1000 is comparable to other power stations across the world.

647 Westinghouse estimates that the radiological impact from representative 12-month plant discharge of iron-55, cobalt-58, cobalt-60 and nickel-63 to sea will result in a dose to the local fisherman family of 0.67 μSv y^{-1}. (ER table 5.2-12)

648 We have independently calculated limits for discharges of cobalt-60, caesium-137 and ‘all other radionuclides (excepting tritium, carbon -14, cobalt-60 and caesium-137)’ that we may grant and, based on the information Westinghouse has provided for GDA, our

proposed disposal limits for activation and fission products by discharge to the sea in any 12 rolling calendar months are:

a) cobalt-60 – 0.5 GBq;

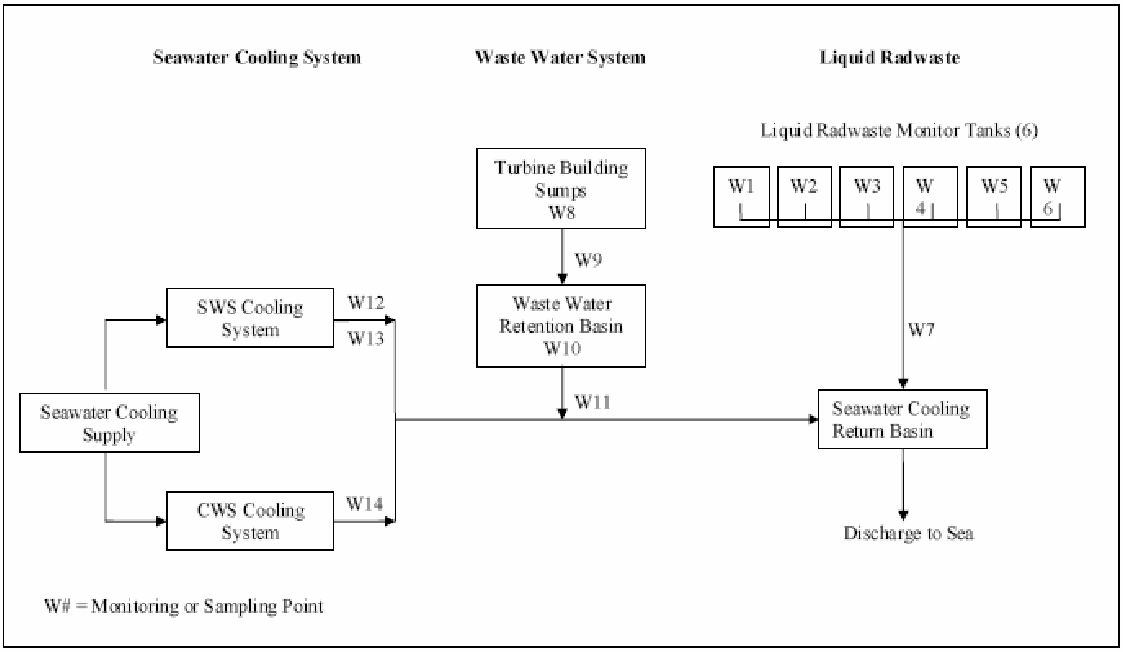
b) caesium-137 – 0.05 GBq;

c) all other radionuclides (excepting tritium, carbon-14, cobalt-60 and caesium137) taken together – 5 GBq.

649 Based on the information Westinghouse has provided for GDA, our proposed quarterly notification level for cobalt-60 is 0.18 GBq, for caesium-137 is 0.018 GBq and for 'all other radionuclides (excepting tritium, carbon-14, cobalt-60 and caesium-137) taken together' is 1.8 GBq.

9.4 Aqueous radioactive waste disposal to the environment

650 The effluent system of the AP1000 is shown in ER Figure 6.2-2:



651 If we permit aqueous radioactive waste discharges from an AP1000 reactor at the site-specific stage, we would place controls on four effluent release points in a permit:

a) W7 – discharge for liquid radwaste monitor tanks serving the WLS;

b) W11 – discharge line of the wastewater system (WWS) from the wastewater retention basin;

c) W14 – discharge line of the circulating water system (CWS);

d) W12 – discharge line of the service water system (SWS).

652 Treated radioactive effluent from the WLS is collected in six monitor tanks, each with a usable capacity of 57 m^3, located in the radwaste building. Westinghouse claims that the average daily radioactive liquid waste arisings are approximately 8 m^3. The monitor tanks will, therefore, provide up to 42 days typical storage capacity in normal operation. This storage period will be longer for most operations but reduced for short periods during higher discharges associated with refuelling. (ERs3.4.3.6)

653 There are no direct continuous discharges from the WLS to the sea. When a tank needs to be discharged, its contents are sampled and analysed. Data on the volume and activity of contained radionuclides are used to decide if discharge can be permitted. All data will need to be recorded as operational records – a permit condition. The monitor tank discharge pumps have a design flow rate of 22.7 m^3 h^{-1}. We will require the final common discharge line to be fitted with an MCERTS (our certification system for measuring equipment) flowmeter and flow proportional sampler to provide permit compliance data, our release point W7. A radiation monitor will also be installed on the discharge line.

654 The disposal route is initially to join the high volume direct sea water cooling flow (136,275 m^3 h^{-1}). The combined flow is then sent to an outfall discharging some distance out from the shore. While we do not accept dilution as a reduction technique, once discharges have been minimised by other techniques, pre-dilution in a large flow before discharge to the environment is acceptable to reduce initial concentrations before dispersion in the receiving waters.

655 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.

656 The WWS, the CWS and the SWS should contain only non-radioactive wastewater in normal operation. Only in the event of steam generator tube leaks is there any possibility of these waters being contaminated with radioactivity.

657 The WWS collects normally non-radioactive waste water into the turbine building sumps. There is a radiation monitor (W9) on the common discharge line from the sumps to the wastewater retention basin (WWRB). If activity is detected the wastewater is diverted to the WLS.

658 The contents of the WWRB are only discharged intermittently after sampling and analysis to confirm discharge can be permitted. The discharge line will need to be fitted with an MCERTS flowmeter and flow proportional sampler to provide permit compliance data, release point W11.

659 The CWS is a high volume once through seawater cooling system for the main condensers. There will be a sampling point on the discharge of this system, release point W14. We believe the risk of radioactivity at this point will be minimal and do not intend to impose any disposal limits. Periodic spot sampling will be required at W14 to confirm no significant contamination has taken place.

660 The SWS is a much lower volume once through seawater cooling system for cooling water used for cooling components in the turbine building. There will be a sampling point on the discharge of this system, release point W12. There will also be a continuous radiation monitor installed at W13. If radiation levels detected are above acceptable levels the operator will need to take action. We believe the risk of radioactivity at this point will be minimal and do not intend to impose any disposal limits. Periodic spot sampling will be required at W12 to confirm no significant contamination has taken place.

661 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.

662 There were queries at our stakeholder seminar about discharge to an estuary. Westinghouse 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 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.

663 COMARE (GDA130) 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 AP1000 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 seawater return basin and consider this adequate protection. Such arrangements exist at existing nuclear power stations.

9.5 The Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR)

664 Several respondents (GDA83, 99, 134, 150 and 156) 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.

665 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[7]. 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.

666 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 Westinghouse to demonstrate that the AP1000 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.

667 This document has set out our conclusions that the AP1000 design uses BAT to minimise some discharges of radioactivity to the sea. The AP1000 GDA design does not have the capability to treat aqueous wastes that are incompatible with ion exchange and relies on mobile plant being brought in when needed. Evaporation is a technique that may be applied to most aqueous wastes. We need to ensure that any

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[7] Ministerial Meeting of the OSPAR Commission, Summary Record OSPAR 98/14/1-E, Annex 35.

power plant built uses BAT to treat and minimise all discharges of aqueous waste. Future operators will be responsible for aqueous waste management and disposal and will need to make decisions on techniques to be used at their sites. We have already raised this issue in chapter 7 above, the assessment finding AP1000-AF04:

a) Future operators shall, at the detailed design phase, provide an assessment to demonstrate that techniques to minimise the discharge of all aqueous radioactive wastes are BAT for their location. In particular, the omission of an evaporator will need to be justified. (AP1000-AF05)

668 The impact of radioactive discharges to the marine environment from the AP1000 design will be less than the currently operating nuclear power plants in the UK.

669 We do not have information on the effect of abatement on carbon-14 contained within the aqueous wastes treated. 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, during the detail 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. (AP1000-AF06)

670 We have set out our assessment of the impact of radioactive discharges to the sea from the AP1000 in chapter 13 of this document. We conclude that doses to the public (less than 1 μSv y^{-1} – our Table 13.3) from the AP1000 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

671 Our conclusions are unchanged since our consultation, however, we have reworded our assessment findings and added an additional one related to waste conditioning plans.

672 **We conclude that:**

a) **Westinghouse has identified all LLW and ILW waste streams that an AP1000 will typically produce.**

b) **The AP1000 uses BAT to minimise the arisings of LLW and ILW, subject to assessment finding AP1000-AF08.**

c) **The AP1000 uses BAT to treat and condition LLW and ILW prior to disposal, subject to assessment finding AP1000-AF09.**

d) **The AP1000 is not expected to produce LLW or ILW for which there is no foreseeable disposal route.**

e) **Westinghouse has 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).**

673 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 Westinghouse's plan for disposability of ILW (AP1000-AF07).

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) (AP1000-AF08). Prior to consultation we only proposed as assessment finding relating to the disposal of LLW and ILW (UK AP1000-AF-09, 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) (AP1000-AF09).

10.2 Background

674 In its submission, Westinghouse describes how low level waste (LLW) and intermediate level waste (ILW) will be generated, managed and disposed of throughout the facility's lifecycle. Westinghouse has also provided basic evidence of how it 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.

675 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 GDA stakeholder seminar and these are also considered in this chapter.

10.3 Creation of solid waste

676 The sources of solid radioactive waste generated in the AP1000 are summarised in Table 3.5-1 in the ER and a detailed breakdown of the wastes can be found in Appendix A of the ER.

677 Westinghouse provides information in section 3.5.3.1 of the ER about LLW, which includes dry active wastes, general trash and mixed waste as a result of normal plant operation. Section 3.5.3.1 of the ER states that waste will generally contain: plastics, paper, metallic items, clothing, rubber, filters, redundant equipment, glass and wood.

678 In section 3.5.3.2 of the ER, Westinghouse states that ILW comprises mainly of spent ion exchange resins, activated carbon and used filters. It states that the production of these wastes is intermittent and associated with replacement and maintenance procedures.

679 The quantities of solid radioactive waste generated by the AP1000 are summarised in ER Table 3.5-1.

680 Westinghouse states in ER section 3.5.3 that the solid radioactive waste estimates in the ER are best, realistic estimates. A major source of information for its calculations was consultations with experienced personnel who have worked in the design of the AP1000 and worked on existing plants.

681 The estimated gross annual volumes of solid LLW produced during the operation and maintenance of the AP1000 is 175.6 m^3 and the estimated volume of treated LLW to be disposed of or stored per year is 72.73 m^3. Therefore, for the conditioned waste, assuming the AP1000 design is for a single, pressurised water reactor (PWR) capable of generating in total 1117 MW of electricity, the estimated volume is 65.1 m^3 per 1000 MWe plant-year of operation. We note that this figure is higher than the 54.7 m^3 quoted in our consultation document because of the design changes to the radiologically controlled area ventilation system (VAS) (see the 'Ventilation systems' section in this document).

682 The estimated gross annual volumes of solid ILW produced during the operation of the AP1000 is 10.25 m^3 and the estimated volume of final solid ILW packages to be disposed of or stored per year is 40.86 m^3. Therefore, for the conditioned waste, assuming the AP1000 design is for a single, pressurised water reactor (PWR) capable of generating in total 1117 MW of electricity, the estimated volume is 36.6 m^3 per 1000 MWe plant-year of operation.

683 The IWS states that solid ILW decommissioning waste will be handled in a similar way to that used for operational and maintenance waste, but with a size reduction stage incorporated to allow larger waste items (for example, structural steel) to be processed into a form that allows immobilisation.

684 The quantities and classification of decommissioning waste associated with the AP1000 are shown in Appendix A3, Appendix A4 and Appendix A6, and summarised in Table 3.5-10 of the ER. An estimated volume of LLW from decommissioning is around 5500 - 6000 m^3. An estimated volume of ILW from decommissioning is 800 m^3. A typical schematic for treatment of decommissioning waste is shown in

Figure 3.5-21 of the ER.

685 The estimates in Westinghouse's submission for the volumes of operational LLW and ILW appear to be reasonable for the AP1000. These estimates were derived by Westinghouse using information from consultations with experienced personnel who have worked in the design of the AP1000 and worked on existing plants. Additionally, Westinghouse has provided a comparison of its estimated solid radioactive waste arisings against available operating plant experience in its response to TQ AP1000-383. This supplementary information provides confidence that the estimates are realistic for the UK AP1000.

686 The Health Protection Agency (HPA) (GDA88) made the following comment about the UK EPR design that is also applicable to the AP1000; 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 the estimates with independently collated data. We can confirm that this reference is available via the Imperial College London library service.

687 The Committee on Medical Aspects of Radiation in the Environment (GDA130) 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 Westinghouse has only provided basic evidence of how it 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 (AP1000-AF07). 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 (AP1000-AF08).

688 An individual respondent (GDA14) commented that the amounts of solid wastes are small in comparison to previous UK reactors, and the conclusions seem sound.

689 The Institution of Mechanical Engineers (GDA146) notes that the annual levels for LLW and ILW exceed the European Utility Requirement but they would expect this to be resolved in the site-specific review. This is a matter that we will assess at the site-specific permitting stage.

10.4 Management and disposal of low level waste

690 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).

691 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.

692 We summarise below the information presented in Westinghouse'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.

693 A schematic of solid AP1000 waste management is given in Figure 3.5-2 of the ER, repeated below as Figure 9.1.

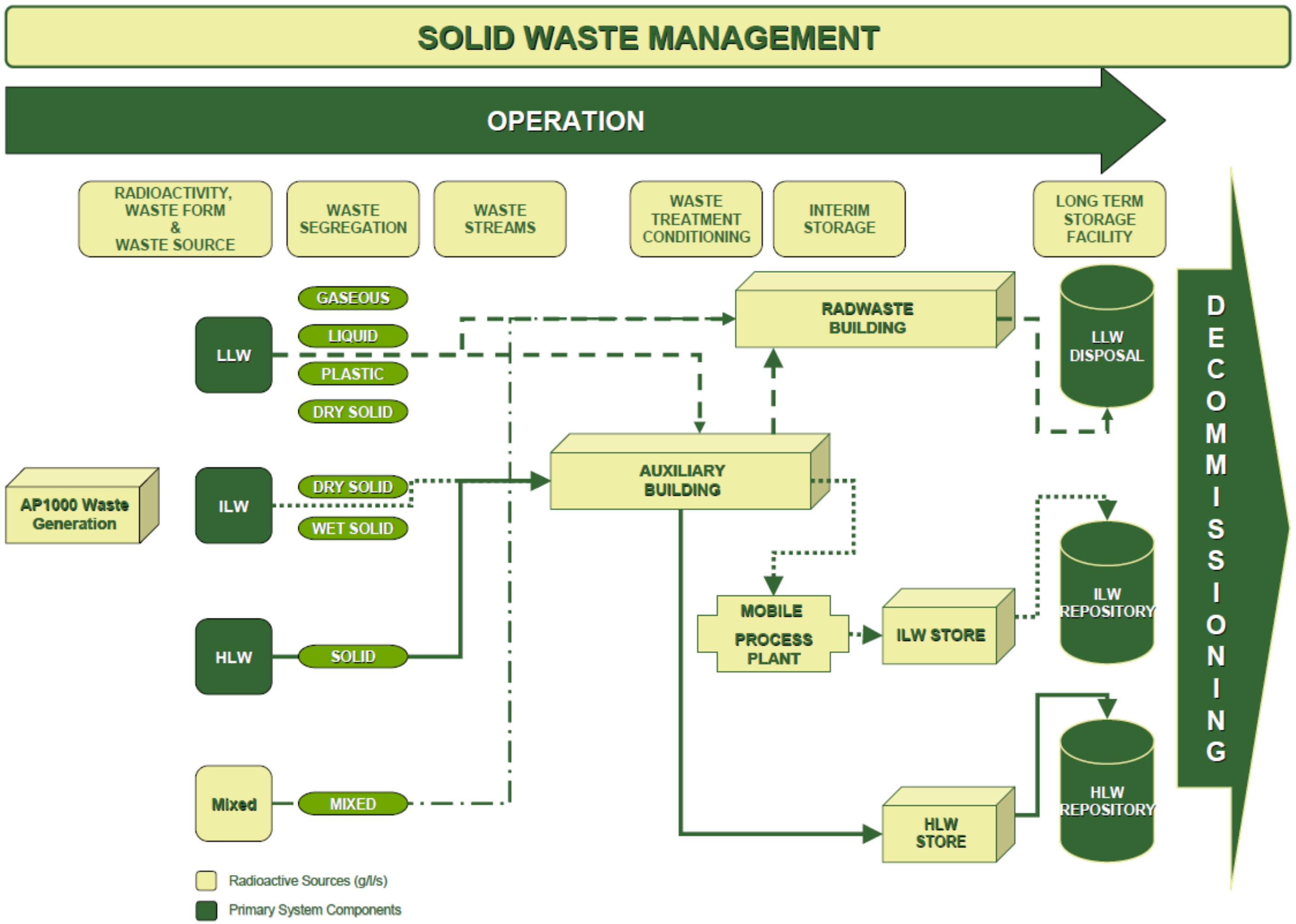

Figure 9.1: Solid AP1000 waste management (ER Fig 3.5-2)

694 Waste treatment of LLW is described in section 3.5.7.1 of the ER. LLW will be brought into the radwaste building and sorted to segregate the waste. Whenever possible, Westinghouse claims that waste items will be decontaminated to the extent that allows handling as conventional waste. It also states that compactable LLW items will be sorted and compacted in metal 200 litre drums and non-compactable items will be cut into pieces to allow packing into metal 200 litre drums.

695 Westinghouse states in ER Section 3.5.7.1 that contaminated material that may arise from equipment replacement parts, tools and other metallic, plastics or cloth parts from outage operations would normally be classified as LLW. However, in the event that they were initially classified as ILW, the AP1000 plant includes provisions for the decontamination of these types of materials so that they can be decontaminated to a LLW category if feasible.

696 A schematic of the LLW processing in the radwaste building is given in Figure 3.5-9 of the ER.

697 In section 3.5.7.1 of the ER, Westinghouse states that full drums containing LLW will be assayed with a low resolution gamma spectroscope (LRGS) and placed into half height ISO (HHISO) containers. HHISO containers will be stored on site in the LLW buffer store before being shipped to the LLWR. Westinghouse states in its IWS that the combined capacity for HHISO containers within the buffer store and the radwaste building will provide up to two years of waste arisings. Off-site incineration is considered for certain LLW, for example, waste oil. Solid LLW disposal routes are shown in Figure 3.5-10 in the ER and a schematic of LLW oil disposal is in Figure 3.5-12 of the ER.

698 In section 3.5.1.3 of the ER, Westinghouse states that a range of appropriate options for waste treatment, such as evaporation, drying, incineration and cement encapsulation, were considered at an optioneering workshop. It documented the results of this workshop and the chosen options were substantiated. Further details of this BAT workshop that formed a part of its BAT assessment and a summary of the BAT workshop report are given in section 3.5.5 of the ER. There is a schematic of LLW options in Figure 3.5-3 of the ER. The study recommended that compaction is adopted as the design option for the treatment of LLW. There is also a schematic of the summary of the selected BAT treatment systems for ILW and LLW waste in Figure 3.5-8 of the ER.

699 Disposal of LLW is briefly discussed in section 3.5.9.1 of the ER. Westinghouse will dispose of LLW to the LLWR. Westinghouse's IWS assumes that the national LLWR is available within two years of site operations commencing.

700 Westinghouse has completed LLWR form D1s (Request for Agreement in Principle to dispose of radioactive waste at the LLWR) for each of the AP1000 LLW streams. These forms describe the nature of the process producing the waste, the type of radioactive waste generated, the physical and chemical form of the waste, and its radiological characteristics.

701 Westinghouse has provided us with signed form D1s from the LLWR, giving agreement in principle for the treatment / disposal of the following LLW:

a) Condensate polishing (CPS) resin;

b) general LLW;

c) waste oil;

d) steam generator sludge.

702 The LLWR recognises that Westinghouse'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 Westinghouse's application against its current arrangements and can give agreement in principle on the basis that this waste would be suitable for treatment / disposal against its current arrangements.

703 Although form D1s have been completed for all AP1000 operational LLW (CPS resin, general LLW, waste oil and steam generator sludge), Westinghouse has identified waste streams that are likely to be suitable for incineration to minimise the waste sent to the LLWR. The CPS resin form D1 was included as a contingency, as generally they are not expected to be contaminated, and are proposed to be treated in the high temperature incinerator at Fawley. The form D1 considers the case if the resin contamination prevents it from being accepted at this incinerator.

704 Off-site incineration is also considered for waste oil as described in ER section 3.5.7.1. Waste oil will normally be non-radioactive, however, in the event of the oil becoming contaminated with radioactivity it will be shipped to an appropriate incineration facility (for example, the Tradebe Incinerator at Fawley). Westinghouse has carried out a review of this contaminated oil against the conditions of acceptance of this incinerator and shown that they can be met. However, Westinghouse states in section 3.5.7.1 that if any waste oil exceeds the radioactivity acceptance thresholds of the incinerator, it will be solidified by mobile plant before being disposed of to the LLWR. We note that we would need a BAT assessment to consider other options. We have an assessment finding on this (AP1000-AF09).

705 Westinghouse has considered the treatment and disposal of large, one-off solid radioactive waste items that could need replacing during the operation of the AP1000. It considers steam generators and reactor pressure vessel heads. Westinghouse states in section 3.5.7.1 that steam generators will be LLW and that they will be reduced in size in a temporary facility, placed in HHISO containers and sent for disposal at the LLWR. Westinghouse states in ER section 3.5.7.1 that the reactor pressure vessel head is not likely to have to be replaced during the operating lifetime but, if it is necessary, it will be treated in a similar way to steam generators.

706 In section 3.5.1.1 in the ER, Westinghouse summarises its waste minimisation strategy. It states that waste minimisation is an inherent part of waste management and that waste is minimised by:

a) the design: The AP1000 was designed with fewer valves, pipes, and other components so less waste will be generated during maintenance activities (repair and replacement) and decommissioning.

b) material selection: For example, the level of cobalt in structures is limited to limit the activation of metal components, and surfaces (including steel wall and floor surfaces) will be sealed to prevent penetration and to facilitate decontamination.

707 In section 3.5.4.1 of the ER, Westinghouse states how the basic AP1000 design principles minimise the creation of LLW during operations and decommissioning, which are:

a) good housekeeping;

b) operating procedures;

c) segregation;

d) volume reduction;

e) sealed surfaces (including steel wall and floor surfaces) to prevent penetration and to facilitate decontamination;

f) limiting the amount of material brought into containment;

g) training all staff allowed to enter radiation controlled areas;

h) providing waste facilities immediately outside of the radiation controlled areas, for the disposal of unnecessary packaging materials;

i) providing tool stores within the reactor containment area (RCA), to prevent contamination of clean tools brought in from outside;

j) testing filter performance to ensure filters are only replaced when necessary;

k) providing radioactive waste advice on radiation work permits.

708 In section 3.5.5 of the ER, Westinghouse provides details of the BAT assessment that has been carried out on the radwaste treatment system. This addressed the waste activities from the transportation point of the 'nuclear island' through to dispatch to the ILW storage before disposal or to the LLW disposal.

709 Westinghouse states in its IWS that within the design of the AP1000, there are many features that facilitate the eventual decommissioning of the plant. For example:

a) reduced equipment numbers reduce the amount of waste that needs managing;

b) carefully selecting materials reduces activation of equipment and structure;

c) reduction in activated corrosion products by improved control of primary circuit water chemistry (pH range; 6.9-7.4) and suitable dosing regimes; for example, zinc acetate.

710 Westinghouse has provided evidence in its BAT assessment that BAT has been used to prevent and minimise at source generation of radioactive wastes for the AP1000. This includes information such as how the control of the choices of materials in contact with the primary coolant leads to a reduction in the production of corrosion products. Having reviewed this information, we accept that the AP1000 uses BAT to minimise the arisings of LLW subject to assessment finding AP1000-AF07.

711 Ingleby Barwick Town Council (GDA39) provided the following response to our consultation: '*The reduction of and handling technique of solid radioactive waste will largely depend on good housekeeping. Strict controls are required to prevent human error*.' We agree with these statements. 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 (AP1000-AF08 and AP1000-AF09). Subject to these assessment findings, we are satisfied that the AP1000 uses BAT to minimise the arisings of LLW and ILW and uses BAT to treat and condition LLW and ILW prior to disposal.

712 Maldon Town Council (GDA51) provided the following response: '*AP1000 we note that Westinghouse has provided basic evidence only. 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

Westinghouse has only provided basic evidence of how it 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 (AP1000-AF08). 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 (AP1000-AF09).

713 Several respondents, including the Nuclear Legacy Advisory Forum (NuLeaf) (GDA81), Somerset County Council (GDA162), Cumbria County Council (GDA167), West Somerset Council and Sedgemoor District Council (GDA155), 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.

714 Suffolk Coastal District Council (GDA165) responded to our consultation stating that it supports the response from NuLeaf (GDA81), 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.

715 Horizon Nuclear Power (GDA128) provided the following response with respect to the issues raised in our consultation document on LLW: '*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.*' 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.

716 West Somerset Council and Sedgemoor District Council (GDA155) 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.

717 Studsvik UK Ltd (GDA132) provided the following response: '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'. We agree that Westinghouse has only provided basic evidence of how it will

minimise the quantities of LLW and ILW needing disposal. Our assessment findings AP1000-AF08 and AP1000-AF09 address this.

718 Several respondents, including; individual respondents (GDA26, GDA85), Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA71), Springfields Site Stakeholder Group (GDA97), and the Institution of Mechanical Engineers (GDA146) said that they were satisfied with our conclusions on solid radioactive waste.

719 ONR has raised concerns about the size of the radioactive waste facilities. Westinghouse provided further information on the radioactive waste facilities in November 2010, which has been included in UKP-GW-GL-027, Radioactive Waste Arisings, Management and Disposal, revision 2. This included revising the layout of the LLW assay systems and providing a description of the path for each type of waste entering the radwaste building to reduce cross-contamination. However, ONR considered that the amount of space allocated to radioactive waste facilities was not sufficient. Westinghouse provided an outline of a potential strategy for multi-unit sites which argues that systems related to solid radioactive waste management (for example for treatment, storage, and transportation), could be shared between the individual units. Westinghouse claimed that this would mean that better utilisation of space could be implemented by dedicating each of the multiple radioactive waste buildings to treating specific types of waste generated across the site. For example, one radioactive waste building could include equipment to treat site compactable waste, another to package site metallic waste, and a separate building could be constructed for treating site solid radioactive waste. Alternatively, Westinghouse claimed that a separate, dedicated building could be constructed for treating solid radwaste (*ER*s7). ONR view these approaches as adequate for GDA; although detailed development work will be required during the detailed design phase, and have captured this as an assessment finding. We agree with ONR's finding.

720 Westinghouse UK (GDA110) said that it agrees with our preliminary conclusions and that it is committed to resolving any outstanding issues within the GDA process.

721 **We conclude that:**

a) **Westinghouse has identified all LLW waste streams that an AP1000 will typically produce.**

b) **The AP1000 uses BAT to minimise the arisings of LLW, subject to assessment finding AP1000-AF08.**

c) **The AP1000 uses BAT to treat and condition LLW prior to disposal, subject to assessment finding AP1000-AF09.**

d) **The AP1000 is not expected to produce LLW for which there is no foreseeable disposal route. Westinghouse has demonstrated that the waste streams would meet the criteria for disposal in a LLW facility or an incineration facility.**

e) **Westinghouse has provided valid estimates for the annual arisings (during operations and decommissioning) of LLW. The arisings of LLW exceed 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 ≤ 50m^3 per 1000 MWe plant-year of operation, although the operational arisings are consistent with those of comparable reactors around the world (Isukul, 2009).**

10.5 Management and disposal of intermediate level waste

722 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.

723 Although a permit for final disposal may not be required for a considerable time, we expect Westinghouse 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.

724 We summarise below the information presented in Westinghouse'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.

725 A schematic of solid AP1000 waste management is given in Figure 3.5-2 of the ER. Waste treatment of ILW is described in section 3.5.7.2 of the ER and shown in the schematic in Figure 3.5-13.

a) ILW will be segregated on an AP1000 nuclear site in the following ways:

b) ion exchange and spent activated carbon will be monitored and sent to spent resin tanks;

c) replacement filter cartridges and any ILW filters will be placed in a Radioactive Waste Management Directorate (RWMD) approved box.

726 In section 3.5.1.3 of the ER, Westinghouse states that a range of appropriate options for waste treatment, such as evaporation, drying, incineration and cement encapsulation, was considered at an optioneering workshop. It documented the results of this workshop and the chosen options were substantiated. Further details of this BAT workshop that formed a part of its BAT assessment and a summary of the BAT workshop report are given in section 3.5.5 of the ER. There is a schematic of ILW organic resin treatment options in Figure 3.5-4 of the ER and a schematic of ILW filter treatment options in Figure 3.5-7 of the ER. There is also a schematic of the summary of selected BAT for ILW and LLW waste in Figure 3.5-8 of the ER. The solid ILW will be immobilised in a cementitious grout within a RWMD approved container (drums or boxes). Westinghouse's BAT assessment concluded that solid ILW should be encapsulated in cement, stored and ultimately disposed of to a national ILW repository.

727 Hence, the spent ion exchange resin and / or activated carbon will be immobilised in a cementitious grout formulation within a RWMD approved drum. The spent filters, etc., will be immobilised in a cementitious grout formulation within a RWMD approved box. The waste encapsulation will be carried out using a mobile

encapsulation facility on a campaign basis. Westinghouse states that the ILW waste packages will be subject to monitoring checks. They also state that once the cement in the containers has set and passed quality assurance checks, they will be transported to the on-site ILW storage building. The boxes and drums will be stored here until a national ILW repository becomes available. A schematic of ILW treatment and disposal is given in Figure 3.5-13 of the ER.

728 Westinghouse states that the ILW store will be designed for a total inventory of 60 years of operational waste arisings from one AP1000 unit and it will have a 100-year design life.

729 ILW will be stored on the sites in dedicated building(s) until a final disposal site for ILW is opened in the UK.

730 Westinghouse states in ER section 3.5.8.2 that when a national ILW repository becomes available, it will monitor the waste packages before transportation. If the results of a package indicates that the radionuclides in the package have decayed such that the package could be LLW, the package will be temporarily placed in a LLW storage area. If suitable, these will be disposed of to the LLWR, which will reduce the final quantities of ILW to be disposed of. However, Westinghouse expects that all waste packages sent to the ILW store will remain ILW.

731 Disposability of operational ILW is briefly discussed in section 3.5.9.2 of the ER. In order to assess the disposability of ILW, Westinghouse provided the Nuclear Decommissioning Authority (NDA) with a datasheet for each of the AP1000 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. Westinghouse has provided us with datasheets for the following operational waste types:

a) filter cartridges (ILW);

b) primary resins (ILW);

c) mixed resins (ILW).

732 Westinghouse has provided us with a datasheet for decommissioning waste.

733 Westinghouse has obtained and provided to us a view from the RWMD of the Nuclear Decommissioning Authority (NDA) (as the UK authoritative source) on the disposability of its 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 AP1000 (See Schedule 1 of Annex 1). Westinghouse also provided the Regulators with its critique of the RWMD disposability assessment, and this is available on its website.

734 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.'

735 The Regulators requested Westinghouse to make a case for the disposability of spent fuel and ILW, which demonstrates the following:

a) How the issues identified in its 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

736 We received Westinghouse's response on 1 March 2010. We note in particular that Westinghouse has consulted with potential operators of the AP1000 on when they would expect to address issues and we recognise that, in most cases, these issues will need to be addressed by future operators of AP1000s, rather than by Westinghouse. We note that Westinghouse has consulted with potential operators of the AP1000 on when they would expect to address issues and RWMD on the stages in the LoC process at which it would expect issues to be addressed.

737 Since our consultation was published, Westinghouse has provided further information in December 2010 on its 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.

738 In general, we consider the plans proposed by Westinghouse, outlining how and when it 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.

739 We note that Westinghouse has produced a 'RWMC Evidence Report', 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 some assurance at this stage that RWMCs can be compiled at relevant stages in the development of an AP1000 fleet, which is sufficient at this stage of the GDA process.

740 In December 2010, Westinghouse provided an updated 'RWMC Evidence Report' for ILW, which incorporates comments from the Regulators and a review of all relevant documents that have been submitted as part of GDA since the original evidence report 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 an AP1000 fleet.

741 We have assessed this further information on disposability from Westinghouse and its RWMC evidence report 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 Westinghouse's plan for disposability of ILW (AP1000-AF07).

742 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 and our conclusions are consistent.

743 Westinghouse states in section 3.5.4.2 of the ER that ILW will be minimised by the following activities:

a) optimum operation of the reactor in terms of power generation per tonne of fuel;

b) select fuel with minimal potential for fuel defects, thereby minimising the radioactive isotope contamination of the primary cooling water circuit. This will reduce load being treated by the ion exchange resin beds and hence the volume of ILW;

c) fuel is received and carefully inspected for any imperfections;

d) minimisation of plant shutdowns;

e) use of grey rods for mechanical shim control;

f) use of canned coolant pumps eliminates seal leaks and creation of radioactive wastewater;

g) selecting materials with a composition low in cobalt;

h) using zinc addition for corrosion control;

i) selecting ion exchange media to give optimum decontamination factor (DF), which will:

j) minimise the number of ion exchange media changes required and reduce the waste volume;

k) give flexibility in routing effluent through the different ion exchange beds to optimise resin uptake.

l) testing filter performance to make sure filters are only replaced when necessary;

m) segregation procedures to prevent dilution of ILW streams by mixing them with LLW streams;

n) formulation trials to determine optimum blend ratio producing the optimum number of waste packages;

o) operating procedures.

744 Westinghouse states in its RWMC document that minimisation is an important initial step in waste management, and AP1000 operational procedures will seek to design, construct, operate, and decommission the plant in such a way that both the waste volume and radioactivity are minimised. It states that this will be achieved on the AP1000 nuclear site by activities such as:

a) optimum operation of the reactor in terms of power generation per tonne of fuel, minimise fuel defects, and hence, minimise the activity of primary cooling water circuit, which in turn, minimises volumes of spent ion exchange resin;

b) good housekeeping: for example, minimising the amount of material brought into containment;

c) selecting ion exchange media to give optimum decontamination factor, which will minimise the number of ion exchange media changes required and reduce the waste volume;

d) formulation trails to determine blend ratio producing the optimum number of waste packages;

e) operating procedures.

745 Westinghouse has provided evidence in its BAT assessment that BAT has been used to prevent and minimise at source generation of radioactive wastes for the AP1000. This includes information such as how the control of the choices of materials in contact with the primary coolant leads to a reduction in the production of corrosion products. Having reviewed this information, we accept that the AP1000 uses BAT to minimise the arisings of ILW subject to assessment finding AP1000-AF08.

746 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 final assessment reports. The final assessment reports are published on our website. Additionally, since our consultation was published, as mentioned above, we received further information from Westinghouse on disposability in December 2010 (see Schedule 1 of Annex 1).

747 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, for GDA, ILW will be stored on the sites in dedicated building(s) until a final disposal site for ILW is opened in the UK.

748 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.

749 Blackwater Against New Nuclear Group (BANNG) (GDA113) 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'. Kent Against a Radioactive Environment (KARE) (GDA148) and Bradwell for Renewable Energy (GDA122) said that they fully endorse BANNG's response to the Generic Design Assessment consultation. The Regulators received additional information from Westinghouse in December 2010 (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.

750 An individual respondent (GDA120) 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 (GDA136) 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 (GDA49) 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 (GDA155) 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. 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: '*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) (GDA134) and the UK and Ireland Nuclear Free Local Authorities (NFLA) (GDA83), both provided the following point in the conclusions of their responses and the Nuclear Consultation Group (GDA150) 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?*'

751 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.

752 Studsvik UK Ltd (GDA132) 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.*' We require evidence during the detailed design phase that the proposed specific techniques for treating and conditioning of ILW before disposal are BAT. This is an assessment finding in our conclusions on solid radioactive waste. Additionally, Westinghouse has considered controlled oxidation (for example steam reforming) in its Radwaste Treatment Options Study Report (see Schedule 1 of Annex 1).

753 Nuclear Waste Advisory Associates (GDA134) and the UK and Ireland Nuclear Free Local Authorities (GDA83), 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*'. 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.

754 The UK and Ireland Nuclear Free Local Authorities (GDA83) provided the following comment on waste in their response and the Nuclear Waste Advisory Associates (GDA134) and Greenpeace (GDA152) 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?' 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 Westinghouse in its critique (opinion) of the disposability assessment. Westinghouse now has the full disposability assessment, including Appendix B and its critique on its web site.

755 Nuclear Waste Advisory Associates (GDA134) and the UK and Ireland Nuclear Free Local Authorities (GDA83), 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.*' 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.

756 The UK and Ireland Nuclear Free Local Authorities (GDA83) provided the following comments on waste disposal in their response and the Nuclear Waste Advisory Associates (GDA134) 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 EA 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 (GDA150) also quoted this from NFLA.

757 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 also mentioned above, we have received additional information from Westinghouse in December 2010 (see Schedule 1 of Annex 1). We have assessed this further information 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 Westinghouse's plan for disposability of ILW (AP1000-AF07).

758 The Institution of Mechanical Engineers (GDA146) 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*.' 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.

759 Horizon Nuclear Power (GDA128) 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*.'

760 The Regulators received additional information from Westinghouse in December 2010 (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.

761 Several respondents, including; individual respondents (GDA26, GDA85), Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA71), Springfields Site Stakeholder Group (GDA97), Horizon Nuclear Power (GDA128) and the Institution of Mechanical Engineers (GDA146) said that they were satisfied with our conclusions on solid radioactive waste.

762 The Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA71) 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.

763 The Institution of Mechanical Engineers (GDA146) said that they fully support the requirement for a disposability assessment of ILW following longer term interim storage pending disposal as the uncertainty surrounding the ILWR means we must have assurance of the efficacy of long term interim storage. Again, as stated above, the Regulators received additional information from Westinghouse in December 2010 (see Schedule 1 of Annex 1) that we have assessed and this is discussed above.

764 We note that ONR has some assessment findings on the continued development of the technical basis for the long-term management of ILW. We support these assessment findings.

765 As mentioned above, in our sections on LLW, ONR has raised concerns about the size of the radioactive waste facilities. We agree with ONR's finding on this matter.

766 Westinghouse UK (GDA110) said that it agrees with our preliminary conclusions and that it is committed to resolving any outstanding issues within the GDA process.

767 Westinghouse has provided valid estimates for the annual arisings (during operations and decommissioning) of ILW. The arisings of ILW exceed 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 ≤ $50m^3$ per 1000 MWe plant-year of operation, although the operational arisings are consistent with those of comparable reactors around the world (Isukul, 2009).

768 On the basis of the information provided for GDA, we see no reason at this stage to believe that any of the ILW from an AP1000 reactor will not be disposable in a suitably designed and located GDF. **We conclude that the AP1000 design is not expected to produce ILW for which there is no foreseeable disposal route.**

769 **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 RWMCs, supported by appropriate stage LoCs, can be developed for all ILW on the timescales identified in Westinghouse's plan for disposability of ILW (AP1000-AF07).**

11 Spent fuel

11.1 Conclusions

770 Our conclusions have been updated since our consultation.

771 **We conclude that Westinghouse have:**

a) **demonstrated BAT in the fuel design for the AP1000 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.**

772 **We also conclude, based on the further evidence provided on Westinghouse's management plans for the fuel including storage, that the AP1000 is not expected to produce spent fuel for which there is no foreseeable disposal route.**

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

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, if the Westinghouse reference dry spent fuel storage system is not chosen. The future operator shall provide an assessment to show that the techniques proposed are BAT. (AP1000-AF10)

b) The future operator shall provide confidence, before the commissioning phase, 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 Westinghouse's plan for disposability of spent fuel. (AP1000-AF11)

11.2 Background

774 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.

775 Although a permit for final disposal may not be required for a considerable time, we expect Westinghouse 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.

776 We addressed comments we received on spent fuel from the public involvement process relating to the AP1000 design by 4 January 2008 in our preliminary assessment report (Environment Agency 2008a). Public comments on this subject 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. Westinghouse's response was that the exact model of the spent fuel cask to transport spent fuel for processing or disposal has not yet been chosen. It is stated, however, that the cask selected will meet the requirements of IAEA and UK standards for design and construction. The cask chosen will have been shown to survive a sequence of four simulated accident conditions involving impact, puncture, fire and submersion in water. Both during and after the tests, the cask must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear reaction.

777 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.

778 These responses have been shared with ONR given its lead regulatory role in regard to safe storage of wastes including spent fuel.

779 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

780 The AP1000 reactor core comprises 157 fuel assemblies. Each fuel assembly consists of 264 fuel rods in a 17x17 square array. The fuel rods consist of pellets of slightly enriched uranium dioxide contained in a zirconium based alloy, Zirlo tubing, which is plugged and seal welded at the ends to encapsulate the fuel. The fuel rods include integral fuel burnable absorbers which may be boride coated fuel pellets. The reactor control system uses rod cluster control assemblies (RCCAs), grey rod cluster assemblies and burnable absorber (BA) rods. The RCCAS and grey rod cluster assemblies include rodlets made from silver / indium / cadmium alloys. The BA rods consist of borosilicate glass tubes with stainless steel tubular cladding. Core reactivity is controlled using boric acid which acts as a chemical poison dissolved in the coolant, RCCAs, grey rod cluster assemblies and burnable absorbers. The initial enrichment of new fuel is up to 4.95 per cent in weight uranium-235.

781 Some attendees to our 6 July stakeholder seminar asked for details of the fuel used for both designs. Information about the Westinghouse fuel can be found in the Environment Report, in Chapters 2 and 3. One of the questions from our stakeholder seminar was whether mixed oxide (MOX) fuel would be used. This has not been put forward for assessment for the AP1000 in GDA, and therefore use of MOX fuel is out of scope.

782 New fuel is stored in the new fuel storage facility within the auxiliary building fuel handling area. New fuel assemblies are moved by the new fuel assembly handling tool into the new fuel assembly inspection area. Following inspection, the accepted new fuel assemblies are stored in the new fuel storage rack (and the spent fuel pool in the case of first time fuelling). The new fuel storage rack includes storage locations for 72 fuel assemblies with the maximum design basis enrichment. The racks include integral neutron absorbing material to maintain sub-criticality. The rack layout provides a minimum separation between adjacent fuel assemblies which is sufficient to maintain a sub-critical array even in the event the building is flooded with unborated water, or fire extinguishant aerosols, or during any design basis event. The rack sits on the floor of the new fuel storage pit which is covered to prevent foreign objects from entering the new fuel storage rack.

783 The new fuel handling crane is used to load new fuel assemblies into the new fuel rack and to transfer new fuel assemblies from the new fuel pit into the spent fuel pool. A gated opening connects the spent fuel pool and the fuel transfer canal. A fuel transfer tube connects the fuel transfer canal to the in-containment refuelling cavity.

784 A new fuel elevator in the spent fuel pool lowers the new fuel to an elevation accessible by the fuel handling machine (FHM). The FHM is part of the fuel transfer system which is used to transport up to two fuel assemblies at a time between the fuel handling area in the auxiliary building and the refuelling cavity in the containment building.

785 The FHM is used to perform fuel handling operations in the fuel handling area. Fuel is placed in a basket in the underwater transfer car to pass through the fuel transfer tube into the refuelling cavity.

786 The refuelling machine performs fuel handling operations in the containment building. Fuel is moved between the fuel transfer system and the reactor vessel by the refuelling machine. It withdraws the fuel from the refuelling cavity, moves over the core area and inserts the fuel assembly into a vacant core location. During refuelling the vacant core location is created by first removing a spent fuel assembly.

787 The initial fuel loading consists of 157 fuel assemblies for one AP1000 unit. Refuelling every 18 months typically requires 64 assemblies for one unit; in fact the range can be between 64 to 68 fuel assemblies depending on fuel enrichment and operating conditions. Spent fuel assemblies are discharged from the reactor at every refuelling outage and are placed into the spent fuel pool. The spent fuel pool has the capacity to store 889 fuel assemblies. Each typical refuelling offload discharges 64 fuel assemblies. The spent fuel pool has the capacity for 10 refuelling offloads, which is approximately equal to 18 years of operation, plus one full core offload.

788 Operating strategies can influence the amount of spent fuel and the radioactivity of the spent fuel. The amount of spent fuel discharged over time is determined by the energy production rate, that is the overall capacity factor including outages, and the discharge burn up limit. Operating utilities may choose from various cycle lengths for AP1000. For example, annual or 18 month cycles. Depending on the requirements of the utility, if the main objective is to reduce the average number of discharge assemblies per year, then on average, an annual cycle would expend fewer assemblies; 40 when compared with 43 on an 18-month cycle. For a plant lifecycle of 60 years, this translates to a generation of 2517 or 2653 spent fuel assemblies for an annual and 18-month cycle respectively. However, depending on the cost of the extra outage every three years, together with the cost of replacement

power during the outage, the impact of outage length on average capacity factor etc, this may not be the most economically efficient operation of the reactor core. Westinghouse states that the majority of its utility customers choose the 18-month fuel cycle.

789 The reference 18-month equilibrium cycle feeds and discharges 64 fuel assemblies every 18 months. On average, this means that approximately 43 assemblies per year are discharged and stored in the spent fuel pool. The cycle is based on an assumed 97 per cent capacity factor and a 21 day refuelling outage. This provides a cycle length of approximately 510 effective full power days. The 18-month reference cycle provides close to the lowest overall electrical production costs.

790 The fuel economics and the amount of spent fuel generated are closely correlated. Both are optimised when the fuel cycle is designed with the fuel being discharged from the reactor as close as is reasonable to the licensed discharge burn up of the fuel. The current licensed limit for Westinghouse fuel in the United States is 62,000 MWD/MTU on the lead rod maximum burn up. However, typically a batch average burn up around 50,000 MWD/MTU is achieved based on inter-assembly power variations and variations of assembly power in assemblies within the same batch.

791 A consultation respondent (GDA38) made a comment for the EPR reactor which is also considered relevant for AP1000. It noted the relatively small amount of (high burn up) fuel used in a new reactor compared with older reactors, and indicated 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 use of high burn up fuel for storage and disposal are considered later in this chapter.

11.4 Management of spent fuel

11.4.1 BAT for fuel design

792 Fission products may diffuse from the fuel and pass through the fuel cladding through diffusion or from leaks into the reactor coolant.

793 The design of the fuel rod and the cladding for the AP1000 design is such that in the event of fuel clad defects, the high resistance of uranium dioxide (UO_2) to attack from water protects against fuel deterioration, although limited fuel erosion can occur. The consequences of defects in the clad are significantly reduced by the ability of uranium dioxide to retain fission products, including those which are gaseous or highly volatile.

794 Zirlo is an advanced zirconium based alloy which has a high corrosion resistance to coolant, fuel, and fission products. Selecting Zirlo cladding materials for the AP1000 minimises defects forming that can result in radioactive releases to the reactor coolant.

795 The BAT forms Westinghouse produced in its BAT final assessment report consider tritium, which arises mainly from ternary fission of the uranium fuel followed by diffusion through the fuel pin cladding into the reactor coolant system (RCS). Westinghouse considers that this source of tritium is unavoidable in systems using uranium as a fuel. Using zirconium, zirlo cladding reduces diffusion of tritium compared with other cladding material options. Using reactor controls, including grey rod cluster assemblies, to minimise the need for changes to the concentration

of soluble boron, and burnable poisons to limit the amount of boron required, are measures that help to minimise the amount of tritium produced in the reactor coolant. The main measures of reducing the formation of tritium relate to the quality of the fuel cladding and minimising fuel defects.

796 The Regulators asked Westinghouse to provide information on the potential actinide content of solid, liquid and gaseous wastes arising from reasonably foreseeable events during the lifecycle of the AP1000. This included the potential for the fuel to contain tramp uranium, that is traces of uranium on the outside of the cladding left over from manufacture of the fuel, and potentially for fuel failure.

797 Westinghouse responded that actinide release to a waste stream is possible if there is a leak in one or more fuel rods. Westinghouse provided information to support low leakage rates from fuel rods for the robust fuel assembly, RFA type fuel. The AP1000 fuel design for UK is based on this RFA fuel, which is an improvement on previous fuel designs in that vibrations in the assembly are reduced. Given the low leak rate from fuel rods there should be little actinide activity in the RCS.

798 Westinghouse provided information from its fuel manufacturing operations in the US. The smear monitoring carried out on the fuel rods confirmed that tramp uranium contamination is insignificant.

799 Ingleby Barwick Town Council (GDA39) commented that '*it is essential that much effort is put into the manufacture of the 1st class fuel as this will reduce the waste produced in the life of the reactor*'. Westinghouse provided information on fuel reliability in ERs3.2.4. The AP1000 fuel design is based on the 17RFA design. '*Since the implementation of the Westinghouse 17x17 RFA in 1998 the overall leakage rate of this design, incorporating all the Westinghouse debris protection features, is 0. The overall leakage rate, on a rod basis, of the basic RFA fuel product including designs that do not use all the debris protection features is less than* 10^{-5}.' (10^{-5} means 10 in a million).

11.4.2 BAT to minimise disposals of spent fuel

800 The Westinghouse BAT final assessment report does not address high level waste (HLW), specifically spent fuel, in detail and refers out to the ER section 3.5. The BAT report includes information on zinc addition to reduce corrosion product transport to the fuel. There is also information on fuel rod burn up, operational cycle, and fuel rod cladding design in regard to minimising emissions at source.

801 The development of the AP1000 design over a 15 year period, including the predecessor AP600 design, involved a number of design decisions that relate to minimising waste and applying BAT.

802 One of these decisions was using zinc addition to reduce the potential for corrosion product transport to the fuel. The AP1000 design includes a chemical and volume control system (CVS) that incorporates a zinc addition sub-system to reduce the rate of corrosion and the release of corrosion products in the reactor coolant system (RCS), which has the potential to cause primary side stress corrosion cracking and crud induced power shift. Zinc addition also reduces the potential release of active corrosion products into the liquid radwaste system. The other benefit of zinc addition is the potential to reduce occupational radiation exposure. We note ONR has raised some concern about reliance on Zn for fuel protection, see chapter 7.

803 The BAT decisions for the longer term interim fuel storage were based on whether to store the fuel wet or dry, also whether to store the fuel above or below ground. Fuel transfers are all carried out underwater. For longer term storage of the fuel in

canisters, Westinghouse notes it is preferable to store fuel under an inert gas atmosphere to minimise the corrosion issues associated with long-term wet storage.

804 Westinghouse claims that underground storage has the advantage of providing greater levels of shielding and a more secure solution with respect to the potential for aircraft impact and other catastrophic events. The disadvantages relate to control of groundwater issues and flood risk. Westinghouse notes these issues will need to be considered at the site-specific design stage.

805 For the generic site, Westinghouse proposes a dry spent fuel storage system to be stored inside an underground cylindrical cavity.

806 Westinghouse has 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 above.

807 In conclusion, we consider Westinghouse have demonstrated BAT in the fuel design and in order to minimise the amount of spent fuel for disposal.

11.4.3 Initial Fuel Cooling in the Pool

808 After spent fuel is removed from the reactor, it will be stored in the spent fuel storage pool to allow radioactive decay to occur and decay heat to be removed. The spent fuel is transferred from the containment building to the spent fuel pool by the fuel transfer system. The fuel handling equipment is designed to handle the spent fuel assemblies underwater from the time they leave the reactor vessel until they are placed into the spent fuel storage pool and eventually in the container for dry storage or shipment from the site.

809 The spent fuel storage pool is located in the auxiliary building and provides storage for spent fuel in borated water with a nominal boron concentration of 2700ppm, to act as a neutron absorber. A spent fuel pool cooling system is provided to remove decay heat generated by the stored fuel assemblies from the water in the spent fuel pool. The decay heat is removed by pumping the high temperature water from within the fuel pool through a heat exchanger, and then returning the water to the pool. A purification system is part of the spent fuel and removes radioactive corrosion products, fission product ions, and dust to maintain low spent fuel pool activity levels during plant operation and to maintain water clarity during all modes.

810 Spent fuel is stored in high density racks which include integral neutron absorbing material to maintain sub-criticality. The racks are designed to store fuel of the maximum design basis enrichment. An assembly cannot be inserted into a location that is full and the design of the racks is such that a fuel assembly cannot be inserted into a location other than a location designed to receive an assembly. The pool contains three region one rack modules, five region two rack modules and five individual defective fuel assembly storage cells. Region 1 racks are used for storage for new fuel and freshly discharged fuel, and Region 2 racks for storage of less reactive fuel.

811 The spent fuel assemblies are usually stored in the pool for some years initially, which reduces fission product activity and decay heat generation. After this retention period, batches of assemblies are transferred to the HLW dry cask storage facility. Since spent fuel is not expected to be reprocessed, a facility for dry spent fuel storage is being offered to operators as part of the reference design.

812 The Institution of Mechanical Engineers (GDA146) noted they would expect further evidence to justify that wet storage of spent fuel for 18 years (as referenced in the ER at the time of our consultation) is BAT. Westinghouse is currently reviewing the time period for storage of spent fuel in the pool as a result of criticality discussions with ONR. The period of storage may be reduced..

11.4.4 Interim Storage of Spent Fuel

813 One of the questions raised at 6 July 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?*'.

814 The options for storage are described in Westinghouse's submission, see ER Chapter 3. 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.

815 Westinghouse has proposed the Holtec underground dry spent fuel storage system, the HI STORM 100U system for interim storage. The spent fuel assemblies are transferred to the storage cask which is designed to shield radiation. The process of loading spent fuel is carried out in a number of steps. The cask handling crane is used to bring in a clean, empty cask to the cask washdown pit where it is washed with demineralised water. The cask lid is removed and stored while the remainder of the cask is washed. The clean empty cask is then properly positioned in the flooded cask loading pit.

816 The fuel handling machine is positioned over the specific fuel assembly to be exported out of the spent fuel storage rack. The fuel assembly is picked up and transported into the cask loading pit. During the transfer process the fuel assembly is always maintained with the top of the active fuel at least 2.9 m below the water surface. This ensures that the direct radiation at the surface of the water from the fuel is minimal.

817 Once the fuel transfer process is complete, the lid is placed on top of the cask to provide the required shielding. The cask is then moved to the washdown pit and cleaned with demineralised water. Decontamination procedures are implemented at this time. When the cask is satisfactorily decontaminated, the cask handling cranes is used to lift it out of the washdown pit in preparation for transfer to the HLW store. During these operations enough water is maintained between plant personnel and fuel assemblies that are being moved to limit dose levels to those acceptable for continuous occupational exposure.

818 The ERs 2.3.6 describes the radioactive waste stores and includes the interim store for spent fuel. The spent fuel store is a seismically qualified below ground storage facility including spent fuel flasks, flask loading equipment, suitable flask transportation vehicles and equipment and below ground storage cells. It will be located within the boundary of the nuclear licensed site and Westinghouse proposes to maintain the potential for extending the store in the future. The proposed location was chosen to minimise the transportation distances between the auxiliary building and the spent fuel store and to facilitate safe transfer of the waste.

819 The Holtec HI STORM 100U system is a vertical, ventilated dry spent fuel storage

system. Westinghouse and Holtec have confirmed that Holtec equipment can fit in the areas of the AP1000 that need to be reached in order to transfer spent fuel from the spent fuel pool to the underground storage area. The system consists of three primary components:

a) HI STORM 100U underground vertical ventilated module, VVM - this provides the storage for multi purpose canister (MPC) in a vertical configuration inside a below ground cylindrical cavity. The main function for the VVM is to provide the biological shield and cooling.

b) multi purpose canister (MPC) – this contains the spent fuel assemblies - the MPCs are identical to those in use in a number of above ground dry spent fuel storage facilities in the USA. The UK Regulators have visited one such above-ground dry spent fuel storage installation as part of an inspection visit during GDA.

c) Hi-TRAC transfer cask which holds the MPC during loading operations.

820 The spent fuel will remain within the HLW store for a determined period of time; at present Westinghouse has allowed up to 100 years. This will enable the heat generating capacity of the spent fuel assemblies to reduce sufficiently to meet the requirements for disposal to the geological disposal facility (GDF).

821 Westinghouse's proposals for storage of spent fuel are based on current practice. Westinghouse states confidence in managing long-term storage on the basis of international experience gained in spent fuel storage, and on the development of dry storage systems where the spent fuel is kept in an inert sealed atmosphere. The Regulators requested further information about the proposed storage facilities to support the long-term safe storage of the spent fuel and to ensure the fuel does not degrade over the long storage period. This was the subject of RO AP1000-74 issued to Westinghouse in April 2010. We consider that Westinghouse provided a satisfactory response to RO-AP1000-74. ONR consider that Westinghouse provide information on the long term management of spent fuel to a level of detail broadly in line with their expectations and that fuel can be stored for the required periods (ONR, 2011c)

822 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.

823 An individual respondent (GDA14) commented that the Westinghouse dry storage proposals appear adequate.

824 The Institution of Mechanical Engineers (GDA146) responded to note its support for the specification of the Holtec underground system for the interim storage of spent fuel.

825 An individual respondent (GDA66) commenting in regard to the EPR design 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'*. This comment is considered applicable to the AP1000 design as Westinghouse propose dry interim storage.

826 HPA (GDA89) 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.

827 A respondent (GDA93) 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.

828 We are satisfied that Westinghouse have demonstrated BAT for storage of spent fuel in the dry interim option 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).

829 Whilst Westinghouse have presented the Holtec dry storage system for interim storage of spent fuel, it will be for the future operator to specify the interim storage method for spent fuel following a period of initial cooling in the pool.

830 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, if the Westinghouse reference dry spent fuel storage system is not chosen. The future operator shall provide an assessment to show that the techniques proposed are BAT. (AP1000-AF10)

11.4.5 Time period for storage of spent fuel and fuel burn up

831 The regulation of storage arrangements of 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 the ONR.

832 Questions raised at the 6 July stakeholder seminar included whether there was certainty on a long term storage facility for spent fuel being available in the foreseeable future.

833 The time period for spent fuel storage was raised in consultation responses. West Somerset Council and Sedgemoor District Council (GDA155) provided one set of answers to our consultation questions for both designs, but generally commenting on the EPR proposals. It noted for the EPR that the specific proposals for storage are for at least 100 years after the spent fuel is first emplaced in the store. Stop Hinkley (GDA157) noted its response is focused on the EPR design but that many of their points are general and would apply equally to the AP1000. It refers to a period of 160 years for on-site storage of fuel - 100 years for onsite storage from the National Policy Statement (NPS) and 60 years of operational life for the reactor.

834 The Welsh Assembly Government (GDA142) and Cumbria County Council (GDA167) 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 (GDA81) 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.

835 The Nuclear Free Local Authorities, NFLA (GDA83) also raised this issue. Another respondent (GDA93) 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.

836 A respondent (GDA120) 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 Westinghouse has provided satisfactory evidence on plans for storage in GDA.

837 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’.

838 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.

839 The period of storage is based on conservative options and a shorter storage period may in fact be needed.

840 The Institution of Mechanical Engineers (GDA146) 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.*’

841 The disposability assessment carried out by RWMD for Westinghouse 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.

842 Questions were raised at 6 July stakeholder seminar about the integrity of fuel with high burn up proposed for use in GDA following long term storage. Dialogue is taking place between the Regulators and RWMD to ensure that the concept for disposal is robust to the disposal of high burn up fuel from new build.

843 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.

844 Suffolk Coastal District Council (GDA165) noted ‘*the longer term potential for the degradation of spent fuel’.*

845 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.

846 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. ONR have included assessment findings in regard to storage of spent fuel.(ONR, 2011c)

847 Stop Hinkley (GDA159) 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 above.

848 Greenpeace (GDA152) responded to our consultation and noted their support for comments made in the submissions by the Nuclear Free Local Authorities (NFLA), and Blackwater Against New Nuclear Group (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.

11.4.6 Final Disposal and GDF

849 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.

850 The designated 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.

851 One of the issues raised at our 6 July stakeholder seminar was '*the UK track record of ignoring problem of what to do with spent fuel i.e. final disposal rather than interim*'.

852 The issue of final disposal of fuel was raised in consultation responses;

853 The Swedish NGO Office for Nuclear Waste Review, MKG (GDA 61). 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?'*

854 Nuclear Waste Advisory Associates (NWAA) (GDA134) 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 AP1000 spent fuel were not dependent on the use of copper and that research into other packaging options and materials will continue.

855 A respondent (GDA93) 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

856 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'*.

857 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.

858 Springfields Site Stakeholder Group (GDA97) 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).'

859 The Institution of Mechanical Engineers (GDA146) commented '*The Institution suggests further options for the final disposal 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*.'

860 Nuleaf (GDA81) also raised issues about spent fuel disposal and the GDF; '*The 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*.'

861 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.

862 The comments raised by the Institution of Mechanical Engineers (GDA146) and Nuleaf (GDA81) on GDF and in "Rock Solid" on deep underground disposal are outside the scope of GDA.

863 Comments were made about the risk of leakage from a GDF. This is outside the scope of GDA.

11.5 Disposability

864 Westinghouse 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 its proposed arisings of spent fuel.

865 RWMD concluded that compared with legacy waste and existing spent fuel, no new issues arise that challenge the fundamental disposability of the wastes and spent fuel expected to arise from operation of the AP1000.

866 RWMD indicated that the disposal route for RCCAs will need to be clarified. The RWMD assessment indicates that 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.

867 The Regulators required further information from Westinghouse on the volume and radionuclides / activity for waste, including RCCAs, redundant irradiated control rods, neutron source assembly and poison rod assemblies, including evidence that they will be disposable. Westinghouse identified RCCAs include 53 assemblies which are replaced once every 20 years. Similarly, there are also 16 grey rod assemblies, which are replaced every 20 years when they become redundant. Both the RCCAs and grey rod assemblies are disposed within the spent fuel assemblies. There are 72 poison rod assemblies that are used in the first core only and then disposed of as waste. There are two primary and two secondary neutron source assemblies. The primary sources are used once during the first cycle then disposed of and the secondary source assemblies are replaced once every 20 years. Westinghouse proposes all for disposal with the spent fuel.

868 Westinghouse provided the Regulators with its opinion/critique of the RWMD disposability assessment considering the impact of the RWMD review on its plans for conditioning, storing and dispatching the waste to a repository (GDF). In its opinion, Westinghouse raised issues including fuel burn up, time for on site storage of spent fuel and availability of a repository.

869 The Regulators requested further information from Westinghouse on how they would address the issues raised in their critique and those issues raised by RWMD in their disposability assessment. Westinghouse were asked to make a case for the disposability of spent fuel and ILW, which demonstrates the following:

a) How the issues identified in its 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.

870 Westinghouse provided information to the Regulators in March 2010. We noted that Westinghouse had consulted with potential operators of the AP1000 design on when they would expect to address issues and we recognise that, in most cases, these issues will need to be addressed by future operators of AP1000s, rather than by Westinghouse.

871 NFLA (GDA83) and NWAA (GDA134) 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 Westinghouse in their critique of the disposability assessment. Westinghouse have placed the full disposability assessment on its web site, including Appendix B. Westinghouse's opinion is also published on its web site.

872 Westinghouse provided detailed responses in regard to disposability in March 2010, and whilst our views were presented in our consultation document, we noted ONR were reviewing this information in its Step 4 assessment.

873 The Regulators also requested information from Westinghouse about long term storage and further supporting evidence from Westinghouse to support the case for disposability of waste and spent fuel. Westinghouse have developed and submitted a plan to the Regulators to support the case for disposability of the waste including spent fuel following storage.

874 In general, we consider the plans proposed by Westinghouse, outlining how and when it and future licensees will address outstanding disposability issues, to be adequate at this stage. We 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.

875 We continued to work with ONR on this, and this work has informed our final decision. We are satisfied that Westinghouse 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 AP1000-I3).

876 We note that Westinghouse has produced a 'RWMC Evidence Report' for HLW (spent fuel), intended to indicate where the information that will be needed for future Radioactive Waste Management Cases (RWMCs) on spent fuel will come from, and when. An updated version of this document (UKP-GW-GL-056 Rev1) responds to comments from the Regulators and takes accounts of developments during the period of GDA. The document gives us sufficient assurance for this stage of the GDA process that RWMCs can be compiled at relevant future stages in the development of an AP1000 fleet.

877 We identified the following assessment finding:

a) The future operator shall provide confidence, before the commissioning phase, that adequate 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 Westinghouse's plan for disposability of spent fuel. (AP1000-AF11)

878 The Regulators requested information on the encapsulation process for disposal of the spent fuel since this was not considered by the RWMD assessment. Westinghouse responded with information, including an outline of the current option for encapsulation of AP1000 spent fuel for dry storage; a description of the spent fuel repackaging system as a way of demonstrating that the necessary technology exists for encapsulating fuel for the GDF; and information relating to the GDF proposed for Sweden which incorporates features in the current reference case for spent fuel disposal in the UK GDF. Section 10 of the radioactive waste management case (RWMC) evidence report for HLW outlines the proposed conditioning and disposability options for spent fuel.

879 NFLA (GDA83) 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.'

880 We will need to see evidence that the spent fuel is capable of being packaged and transported safely, and we require the future operator 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. Westinghouse has provided details of how it might package spent fuel at the reactor sites if necessary, and has reviewed international experience as part of its response.

881 However, we recognise that Westinghouse 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 NIA identifies and briefly considers options for spent fuel packaging but does not propose a definitive position.

882 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 Westinghouse on encapsulation of spent fuel is sufficient to show that packaging for disposal should be feasible.

883 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'*.

884 In its submission, Westinghouse provide reasonable proposals for how spent fuel will arise, be managed and disposed of throughout the facility's lifecycle. Westinghouse provide information on the fuel composition and characteristics, and proposed fuel burn up. Westinghouse considered operating strategies in regard to spent fuel generation, 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. Westinghouse has obtained a view from the RWMD of the NDA on the disposability of the fuel and has provided its opinion/ critique to the Regulators. Westinghouse provided sufficient information and evidence to satisfy our requirements for spent fuel management in GDA.

885 ONR through its Step 4 of GDA continued to work with us to review the information supplied by Westinghouse as they finalised the information contained in their submissions on long-term storage and disposability. We now have further information and evidence from Westinghouse to support the safe storage and disposal of spent fuel.

886 ONR provided advice to us that spent fuel can be maintained in a suitable condition during on-site storage such that it will remain acceptable for disposal (ONR, 2011c).

887 We are satisfied that Westinghouse 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 AP1000-I3).

888 We conclude that the AP1000 is not expected to produce spent fuel for which there is no foreseeable disposal route.

889 However we will expect Westinghouse 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.

890 We stress, however, that we expect to see before any AP1000s begin operation further information from Westinghouse 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 expect much earlier than that to see evidence of sufficient progress to provide reasonable confidence that any issues are likely to be manageable.

891 Respondents (GDA14, GDA26) confirmed they were satisfied with our conclusions on spent fuel management. Springfields Site Stakeholder Group (GDA97) indicated their support and noted that there would need to be an agreement made on Geological Disposal Facility (GDF).

892 The Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA71) 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.

893 Some respondents disagreed with our findings, suggesting no SoDA be given (GDA 53, 134, 152, 156).

894 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.

895 Horizon Nuclear Power (GDA128) 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.

896 Westinghouse (GDA110) responded to our consultation to confirm its commitment to resolve any outstanding issues within the GDA process.

897 One respondent (GDA53) questioned how could we be prepared to issue a draft interim SoDA when it is not known if the fuel is disposable. The Low Level Radiation and Health Conference (GDA156) suggested no SoDA be given pointing to '*inadequacy of some of the information provided-particularly concerning the disposal of a range of wastes'*. Greenpeace (GDA152) suggested we had postponed '*these outstanding disposability issues to some unspecified time in the future*'. Nuclear Waste Advisory Associates (NWAA) (GDA134) responded with a similar view 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 Westinghouse 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 provided since our consultation meets our requirements.

898 The Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA71) stated their support for Environment Agency's decision to issue a draft interim statement of design acceptability (SoDA) 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 in evaluating the disposability of long term stored spent fuel. The evaluation by the Regulators is now complete. We conclude the spent fuel arising from the AP1000 is likely to be disposable.

899 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.

900 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:

901 "*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*."

902 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

903 Our conclusions are unchanged since our consultation, however, we have reworded our assessment finding.

904 **We are unable to conclude that overall the AP1000 utilises the best available techniques to measure and assess radioactive disposals.**

905 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, and meet the requirement for independent 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. (AP1000-AF12)

12.2 Background

906 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 AP1000 to:

a) confirm that discharges are as predicted by the designer;

b) assess compliance with limits;

c) provide good quality data for dose assessments.

907 A number of consultation responses were received in regard to monitoring of radioactive disposals which are discussed 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

908 We summarise below the information presented in Westinghouse'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.

909 Measures for monitoring discharges are described in chapter 6 of the ER and in the

document titled 'AP1000 Generic Design Measurement and Assessment of Discharges' (see Schedule 1 of Annex 1).

910 For the main plant vent, monitoring will be carried out for: particulates, iodine and noble gases, using continuous sampling and an isokinetic sampling nozzle. Grab samples can also be taken for laboratory analysis. The key radionuclides for the monitoring of aerial discharges were identified as tritium, carbon-14, krypton-85 and iodine-131 and other particulate (for example, cobalt-60 and caesium-137). The proposed limits of detection will not meet those required by EU Commission Recommendation 2004/2/Euratom for iodine-131, strontium-90 and caesium-137. The future operator will need to demonstrate that they meet these requirements.

911 Monitoring of tritium and carbon-14 will be required and Westinghouse stated in ER section 6.2.1.1 that a bubbler system for sampling tritium and carbon-14 will be incorporated into the design of the main stack monitoring system.

912 Westinghouse carried out a review against M11 (Environment Agency 1999a) requirements with broad consistency being claimed, and with reference to conforming to American National Standard (ANSI N13.1), although evidence was not provided. It stated that some of the differences were to be addressed at future stages of the design and authorisation process. We will expect arrangements to meet the British and European standards, for example ISO 2889:2010 and EN15259:2007.

913 No formal BAT assessment was carried out by Westinghouse when considering the monitoring options. This is required before the commissioning phase.

914 The design of the stack monitoring system is still being developed and the equipment specifications have not been completed. When the instrument to be used for flow rate measurement has been specified, Westinghouse states in ER section 6.2.1.1 that it will review the MCERTS register to see if a suitable instrument is available. Information on monitoring and flow measurement points and upstream and downstream disturbances and the location of filtration have not yet been determined.

915 The design of the area surrounding the monitoring locations is still being developed, but Westinghouse states in ER section 6.2.1.1 that industry codes and standards along with M1 (Environment Agency 2010a) will be considered. We will require these standards to be met.

916 Westinghouse states in ER section 6.2.1.2 that the AP1000 will have on-site laboratory facilities, but specification of equipment and implementation of processes necessary to gain accreditation to ISO 17025 (BSI 2005) is operator specific.

917 We have assessed the information Westinghouse provided on the AP1000 design for determining gaseous discharges against the requirements of M1 (Environment Agency 2010a) and M11 (Environment Agency 1999a) and other best practice for monitoring.

918 **We have concluded that:**

a) **No formal BAT assessment has been undertaken for the monitoring of gaseous disposals.**

b) **The single sampling point for gaseous disposals does not allow the requirement for independent sampling to be satisfactorily met.**

c) **Not enough information has been provided on the location of the monitoring and flow measurement points, and evidence has not been provided to back up statements about how representative samples would**

be achieved. Therefore, we cannot assess appropriateness of monitoring of gaseous disposals at this stage.

d) **We could not make an assessment on the suitability of the sampling lines. The information is pointing to them being too long as they descend from the sampling points in the stack to the monitoring equipment in the auxiliary building.**

919 At the commissioning phase, we will expect the sampling systems to be compliant with our guidance and appropriate European and British monitoring standards or equivalent.

12.4 Monitoring of aqueous disposals

920 We summarise below the information presented in Westinghouse'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.

921 Measures for monitoring discharges are described in chapter 6 of the ER and in the document titled 'AP1000 Generic Design Measurement and Assessment of Discharges' (see Schedule 1 of Annex 1).

922 There are three discharge streams for aqueous radioactive effluents: the liquid radwaste; waste water; and service water systems. The latter two could contain low levels of radionuclides and are minor discharge routes under normal conditions. All three streams are released through the same pipeline. For the liquid radwaste stream, there will be continuous on-line monitoring for caesium-137 in the discharge pipe. Additionally, samples from the discharge tank will be collected and analysed before discharge. Westinghouse has similar arrangements for the minor streams. Westinghouse states that the key nuclides for monitoring are tritium and a fission product, for example caesium-137, but it only intends to monitor for caesium-137 and its limit of detection (LoD) for this meets the EU Commission (Euratom 2004/2/) required value. Westinghouse states that it could determine the other EU Commission recommended radionuclides tritium, cobalt-60 and strontium-90 by grab samples if required.

923 Westinghouse states that it broadly conforms to the objectives and principles in M12 (Environment Agency 1999b), with some of the differences expected to be addressed at future stages of the design and licensing process.

924 No formal BAT assessment was carried out when considering the monitoring options.

925 Westinghouse states in ER section 6.2.1.2 that the instrument for flow rate measurement has not been specified, but when it has, Westinghouse states that it will review the MCERTS register to see if a suitable, certified instrument is available.

926 Westinghouse has indicated in ER section 6.2.1.2 that the design will be able to accommodate both grab sampling as well as proportional sampling to obtain a representative sample (including provision for separate proportional samplers that can be secured to provide independent measurement) on the discharge lines.

927 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. Westinghouse states in ER

section 6.2.1.2 that all sampling and monitoring equipment will be housed in weather shielded buildings and will be located in areas where access is controlled. It also stated that there will be an on-site laboratory with the capability to be UKAS accredited to ISO17025, but pointed out these would be operator responsibilities.

928 We have assessed the information Westinghouse has provided on the AP1000 design for determining aqueous discharges against the requirements of M12 (Environment Agency 1999b) and other best practice for monitoring.

929 **We have concluded that no formal BAT assessment has been carried out for monitoring aqueous disposals.**

12.5 Monitoring of solid waste disposals

930 Westinghouse has provided limited information on the monitoring of solid waste disposals.

12.6 Monitoring of radioactive disposals – review of consultation responses

931 An individual respondent (GDA26) 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'*.

932 Maldon Town Council (GDA59) said: '*We note that no assessment has been carried out to date*.'

933 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*.'

934 The Institution of Mechanical Engineers (GDA146) said that monitoring equipment is vital to reassure the public and gain acceptance of future stations.

935 Ingleby Barwick Town Council (GDA39) said that it is important that adequate monitoring takes place of radioactive waste.

936 An individual respondent (GDA14) said: '*The picture seems to be 'they haven't got the detail yet and we'll interrogate them thoroughly when they have' - which seems to encapsulate EA's role*'. We require further information and we have reflected this in our conclusions on monitoring of radioactive disposals.

937 Horizon Nuclear Power (GDA128) 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 application. It is Horizon's view that initial information will relate more to principles. 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*.' We require information at an early stage to ensure BAT has been considered so that the AP1000 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.

938 Several respondents, including; an individual respondent (GDA85), the Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA71), Springfields Site Stakeholder Group (GDA97), and the Committee on Medical Aspects of Radiation (GDA130) said that they were satisfied with our conclusions on monitoring of radioactive disposals and recognised our requirement for more information.

939 Westinghouse UK (GDA110) said that it agrees with our preliminary conclusions and that it is committed to resolving any outstanding issues within the GDA process.

13 Impact of radioactive discharges

13.1 Conclusions

940 Our conclusions are unchanged since our consultation, however, we have reworded them to be more concise.

941 **We conclude that:**

a) **Westinghouse's generic site parameters and its values, which define its generic site, are appropriate to use in its assessment of radiological impact at the GDA stage**

b) **Westinghouse has made an adequate assessment of the impact of the discharges which assumes the AP1000 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) that recommends 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 an AP1000 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.**

942 We have assessed the information Westinghouse provided for the AP1000 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.

943 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 AP1000 at the proposed site will be as low as reasonably practicable (ALARP) and below relevant dose constraints and dose limits. The Health Protection Agency (GDA89) 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.

944 We have received several comments about two recent studies and reports on health risks near nuclear sites and from tritium and whether these have been considered.

945 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 Ionising 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.

946 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) and also into risk factors specifically related to tritium (AGIR 2007).

947 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. 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.

948 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 5 years of age living within 5 km of a nuclear power plant in Britain. COMARE has 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.

949 We formally sought advice from the HPA to confirm if our dose factors or methodology should as a result of the Advisory Group on Ionising 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.

950 The HPA has recently recommended a revised dose constraint of 150 μSvy^{-1} (0.15 mSv y^{-1}) for use at the planning stage of new nuclear facilities (HPA 2009).

951 For our regulation we continue to apply dose factors published by ICRP (ICRP 1996) and compare the calculated doses with the legal dose limits and dose constraints (EPR-2010) 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 Westinghouse

952 Westinghouse made two assessments of doses from the AP1000. In its first assessment of the impact on members of the public Westinghouse carried out a single stage of assessment. Its assessment consisted of a refined assessment at stage 2 using our initial radiological assessment system. This was carried out twice; once for representative discharges and once for its proposed limits – which are higher than the representative discharges. Its estimate of doses was 14 μSv y^{-1} for its representative discharges and 20 μSv y^{-1} for the proposed limits. This dose was from the operation of a single AP1000,. This approach is consistent with the principles that have been laid down for dose assessments (Environment Agency et al 2002).

953 Following our consultation, Westinghouse made a second assessment. The revision to the assessment took into account increases to the estimate of effective release height to 40m associated with a Westinghouse approved design change proposal to increase the stack height. In its second revised assessment of the impact on members of the public, Westinghouse carried out a two stage assessment. Its revised assessment used our initial radiological assessment system. Stage 1 applied conservative default data. Stage 2 revised some parameters to take into account characteristics of the reactor design and generic site. The assessment was again carried out twice; once for representative discharges and once for its proposed limits. Its estimate of Stage 2 doses was 9.8 μSv y^{-1} for its representative discharges and 13 μSv y^{-1} for discharges at its proposed limits. This dose was from the operation of a single AP1000, 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).

954 We were able to verify all stages of the first assessment produced by Westinghouse.

955 Westinghouse's estimate of dose is well below the UK constraint for any single new source of 300 μSv y^{-1}, and is also below the dose constraint proposed by the Health Protection Agency (HPA 2009) 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}. On the basis of this relatively low dose, Westinghouse did not carry out a more detailed stage 3 assessment.

956 We made two assessments of dose to verify Westinghouse's original stage 2 assessment and a more detailed stage 3 assessment. Our assessment of the doses from the AP1000 at representative discharges was 14 μSv y^{-1} for stage 2 and 8 μSv y^{-1} for stage 3.

957 Westinghouse assessed the dose to plants and animals near an operating AP1000. It predicts:

a) A very low probability that the dose rate to any terrestrial animal will exceed the screening dose rate of 10 μGy h^{-1} (situation is of negligible radiological concern); ;

b) the highest dose rate for a marine organism to be 25.2 μGy h^{-1} (polychaete worm).

958 We have also made an assessment of radiation dose rates to plants and animals near an operating AP1000. We predict the highest dose rates to be:

a) 0.1 μGy h^{-1} for a terrestrial organism (a bird egg);

b) 0.04 µGy h^{-1} for a marine organism (a mammal).

959 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

960 Westinghouse have made two assessments of the impact of the discharges of radioactivity from the AP1000 to the environment. The second assessment was carried out after our consultation. We have reviewed their first assessment in detail. Our review involved two main processes.

961 The requesting party's initial assessment was based on the methodology in the Environment Agency system (Environment Agency 2006a,2006b). 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.

962 Our first activity was to verify the first assessment Westinghouse provided. The verification was aimed to reproduce the assessment made by Westinghouse, 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 in 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 Westinghouse. We followed up any significant discrepancies with Westinghouse. These processes helped us to be sure that the assessment of impacts on people and the environment were correct and valid.

963 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 reasonable. One respondent, the Institution of Mechanical Engineers (GDA146) agreed '*with the consultation document conclusions and that the assessment section was a good section demonstrating the plant will meet all requirements by a good margin and reassuring to see such good agreement between the Westinghouse data and the regulator's independently calculated data. The Institution feels assured that Westinghouse have assessed fully the impact of radioactive discharges and all dose-rates are well below 40 µGy h-1'.*

964 In 2009 the HPA updated its dose assessment methodology and provided a revised implementation of the method in PC CREAM-08. HPA advised in its 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.

965 After we had completed our verification of the first assessment made by Westinghouse and published it, Westinghouse made a second assessment. The main difference between the first to the second assessment was an increase in the effective release height for discharges to air (from 22 m to 40m) taking into account a Westinghouse approved design change proposal to increase the stack height. We undertook a limited review of the second assessment. Increasing release height has the overall effect of reducing predicted ground level air concentrations and hence reducing doses. In the second assessment the stage 2 doses were

assessed as 9.8 microSv y^{-1} (Table 13.2) compared with the 14 microSv y^{-1} from the first assessment (Table 13.1).

Table 13.1 summary of assessment outputs from the first Westinghouse assessment of the AP1000 and our verification for representative annual discharges

Assessment	Westinghouse calculated dose µSv y^{-1}	Verification of Westinghouse assessment	Our calculated dose using our assumptions µSv y^{-1}
Stage 1	N/A	-	N/A
Stage 2	14+	V	14+
Stage 3	N/A	-	8+
Short duration release to atmosphere	12**	VC	12**
*Dose to the representative person including direct radiation +Sum of doses to the groups most exposed to gaseous and liquid discharges and direct radiation ** units are µSv V – verified – able to reproduce their assessment exactly VC – validated by comparison between our assessment and AP1000.			

Table 13.2 summary of assessment outputs from the second Westinghouse assessment of the AP1000 with an increase in effective release height

Assessment	Westinghouse calculated dose µSv y^{-1}
Stage 1	58
Stage 2	9.8+
Stage 3	N/A
Short duration release to atmosphere	4.9**

13.3 Generic site concept

966 At present, there are no specific sites for which detailed site-specific assessment can be made. At the generic design assessment stage, ahead of an application to build and operate an AP1000 at a particular site, we have requested an assessment to inform us about the potential impact from an operating AP1000. This assessment is based on available information on the design. We have also carried out our own assessment of what the impact could be. To make sure that the assessment is realistic, we have asked Westinghouse 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.

967 We have asked Westinghouse 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 of interest to us include:

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 and other human habits data.

968 Westinghouse has derived its AP1000 generic site characteristics based on information from five coastal nuclear power stations around the UK. The five power stations are Dungeness, Hartlepool, Heysham, Hinkley and Sizewell. Westinghouse considers these sites to be typical of the range of nuclear coastal sites in the UK. Westinghouse has also obtained information from the Government's on-line geographical information system. (ER c5.1)

13.3.1 Westinghouse generic site characteristics and exposed groups

969 Westinghouse's AP1000 generic site characteristics include data on:

a) **Human population** – Westinghouse has analysed the centres of population within 20km of the five power station sites and has assumed that the generic site has the 80th percentile number of population centres within a given distance. It has derived the number of population centres with a population of more than100,000, more than 20,000, more than 5000, more than 1000, equal to or less than 1000 and farms and properties at distances of less than 1km, less than 2km, less than 10km and less than 20km from the generic site. For each size of population, it has identified the closest distance that a population of such a size is to the generic site. Westinghouse chose to use the 80th percentile number of population centres within a given distance as they consider that this gives a conservative yet realistic generic site. (ER Table 5.1-1)

b) **Exposed population groups** – for dose assessment purposes Westinghouse has considered two exposure groups for human population:

   i) The locally resident farming family selected to represent exposure pathways associated with atmospheric releases from the AP1000. The local resident family comprises infants, children and adults who live 100m from the aerial discharge point. They spend most of their time at home, some of which is spent outdoors. They eat food from local sources and milk from local farms which are 500m from the aerial discharge point. They eat locally caught fish and shellfish.

   ii) The fisherman family selected to represent the exposure pathways associated with discharges from the AP1000 to the coastal environment. The fisherman and his family are assumed to spend time on intertidal sediments in the area and consume high levels of locally caught fish and shellfish as well as smaller amounts of locally produced fruit and vegetables from local sources up to 500m from the aerial discharge point. This group live far enough from the site not to be exposed to direct radiation from atmospheric releases.

c) **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. (ER Tables 5.1.2 and 5.1.3). 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.

d) **Meteorology** – Meteorological data has been derived for the generic site from worst-case maximum, worst-case minimum and average data for the five power station sites. Data on atmospheric conditions and atmospheric deposition coefficients have been used which are consistent with data published in recognised sources such as our Initial Radiological Assessment Methodology and IAEA SR19. (ER Table 5.1.5 and 5.1.6.)

e) **Terrestrial environment** – it has been assumed that the highest elevation within 2 km of the generic site is 30m high and within 10km is 358m high. Land cover around the generic site is generally assumed to be arable, grassland, dunes and some woodland. A surface roughness of 0.3m has been assumed which is typical of a rural location. It is assumed the land is stable with few geological faults and the geology is glacial clay with sand and gravel lenses. Perched groundwater is assumed to be 2m below the surface and the generic site overlies a major aquifer with a groundwater level 20m below the surface. Based on British Geological Survey data it has been assumed that the generic site has the potential to experience an earthquake of 6.5 magnitude on the Richter scale. A number of sensitive or designated sites are assumed to be present near the generic site, the nearest being a Site of Special Scientific Interest, which is 180m from the generic site. (ER table 5.1.7, 5.1.8 5.1.9, 5.1.10).

f) **Coastal environment** – tidal ranges have been assumed to be between -0.06m and 11.17m. The volumetric flow rate has been assumed to be 130 m^3s^{-1}, which is the most conservative exchange rate associated with the five power station sites. Sand, gravel, rock, mud and made ground (or combinations of these substrates) which are found at the five power station sites are assumed to be present in the inter-tidal zone. The bathymetry assumed for the generic site assumes water depth in terms of Admiralty Chart Datum to range from -15m to 5m over a distance of 10km from the generic site. A range of marine biological features such as water and wildfowl areas, sensitive fish areas and seabird nesting colonies are assumed to be present within 10km of the generic site. (ER table 5.1.11, 5.1.12, 5.1.13)

970 **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. Westinghouse has assumed that all reference organisms specified in the ERICA 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. Westinghouse has assumed the terrestrial organisms to be located at the site boundary and the marine organisms to be 150m from the discharge point. (ER Table 5.1.4)

971 Westinghouse has used the AP1000 generic site characteristics in its assessment of the potential radiological impact of the AP1000 on members of the public and non-human species.

13.3.2 Our view of the Westinghouse generic site characteristics

972 We have reviewed the Westinghouse generic site characteristics. We believe that they are justified and reasonable and represent a conservative approach, while also being realistic. We consider the parameters and its values that define its generic site are appropriate to use in its assessment of radiological impact at the GDA stage. We recognise that a detailed site-specific assessment of the radiological impact from the AP1000 will be required for any site where the AP1000 is proposed and, therefore, site-specific data will be required for any site at which an AP1000 reactor may be located.

973 **We conclude that Westinghouse's generic site parameters and its values, which define its generic site, are appropriate to use in its assessment of radiological impact at the GDA stage.**

13.4 Our requirements for the assessment of doses to people

974 We have required Westinghouse 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 for carrying out stage 2 assessment is the Environment Agency's initial assessment system. If doses are assessed as above 20 μSv y^{-1}; a more detailed assessment may be required. A more detailed assessment (called stage 3) can be carried out using the EC system described in an EC publication number RP-72 and implemented by the HPA in a computer code PC CREAM 98. Westinghouse has carried out a stage 2 assessment, but has not moved to a stage 3 because the doses are less than 20 μSv y^{-1}.

975 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 constraint, we have estimated doses from direct radiation based on data from Sizewell B in 2007. (Environment Agency, et al, 2008b). ONR will be making an assessment of direct radiation dose as part of its work in Step 4.

976 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 liquid 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 lead 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.

977 Westinghouse provides information on its assessment of doses to the public in its submission.

13.4.1 Westinghouse assessment approach

978 Westinghouse carried out a one-stage approach to its assessment. It is based on 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 liquid 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. Westinghouse made two stage 1 assessments, one using the representative annual discharges from the reactor, and one using their proposed discharge limits.

b) Stage 2 is a more refined assessment using more realistic key parameters such as stack height and liquid dispersion factors. Westinghouse used our published dose per unit release factors in a more realistic way. For gaseous discharges, the effective release height was assumed to be 22.5m, which Westinghouse considers to be realistic. In their second assessment, Westinghouse revised the effective release height to 40 m to take into account an approved design change involving an increase in stack height. This takes into account the physical heights of the release point and building wake effects. A high release height allows more dispersion and results in lower concentrations at ground level. An effective release height of ground level is likely to lead to the highest estimates of dose. For liquid radioactive waste discharges, a key function is dispersion, which is controlled by the amount of water flowing past the release point and exchanging with water around the site. Relatively low exchange rates can lead to higher dose estimates. For liquid 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 five locations around England and Wales chosen by Westinghouse to represent sites where a new AP1000 reactor might potentially be located. Westinghouse made two stage 2 assessments; one using the representative annual discharges from the reactor and one using their proposed discharge limits.

979 Our initial radiological methodology calculates doses to the most exposed members of the public for gaseous and liquid 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.

980 Westinghouse also estimated doses from direct radiation from the AP1000 in order to predict the dose to the representative person.

981 Stage 3 is a more detailed assessment and is usually carried out where stage 2 outputs are above 20 μSv y^{-1}. A stage 3 assessment may also be carried out where doses are lower than this and additional assurances or more detail is needed about predicted doses. Westinghouse did not carry out a stage 3 assessment.

982 We considered the approach and assumptions made by Westinghouse in its dose assessment to be reasonable.

13.4.2 Westinghouse's assessment results

983 Table 13.3 shows the doses Westinghouse predicted.

Table 13.3 Westinghouse first assessment predicted doses for the AP1000 design for representative annual discharges.

Pathway	Doses to the public μSv y^{-1}	
	Stage 2	Stage 3
Liquid discharges	2	N/A
Gaseous discharges	8	N/A
Direct radiation	4	N/A
Total dose	14	N/A
Short duration release to atmosphere+	N/A	12+**

+Assuming 1 month's worth of discharge occurs over 30 minutes.** units are μSv

Table 13.4 Westinghouse second assessment predicted doses for the AP1000 design for representative annual discharges.

Pathway	Doses to the public μSv y^{-1}		
	Stage 1	Stage 2	Stage 3
Liquid discharges	3.0	2.3	N/A
Gaseous discharges	51	3.6	N/A
Direct radiation	4.0	4.0	N/A
Total dose	58	9.8	N/A
Short duration release to atmosphere+	N/A	N/A	4.9+**

984 Westinghouse's first stage 2 assessment resulted in estimated doses to the representative person of the public of 14 μSv y^{-1} (ER Table 14.2).

985 The highest contribution to dose was from consuming carbon-14 in milk resulting from gaseous discharges.

986 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. Westinghouse has made an assessment of a short duration release – assuming one month's discharge is released over 30 minutes. This a conservative assumption in that it is likely to be an overestimate of the discharge made over such a short timescale. This results in an estimated dose from a short duration release from an AP1000 to the representative person of 12 μSv.

987 With the revised effective release height doses are reduced to 9.8 μSv.

988 **We conclude that all the doses Westinghouse 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 Westinghouse assessment results

989 We were able to repeat the stage 2 assessment of the Westinghouse dose assessment except initially for doses due to short duration releases. As a result of our verification exercise, Westinghouse reviewed its assessment of the dose due to short duration release from an AP1000 and provided a revised estimate of 12 μSv. After this verification process was completed, Westinghouse revised its dose assessment to take into account a higher effective release height for discharges to atmosphere, taking into account proposed design changes to increase the stack height. This resulted in lower doses predicted for their discharges to atmosphere.

990 We have also carried out our own more detailed (stage 3) dose assessment, assuming discharges are made at the proposed limits. For this, we used the PC CREAM 98 model and standards practices used by the Environment Agency for regulation under RSA93.

991 Our stage 3 assessment showed the highest estimated doses from an AP1000 is to an infant representative person of 11 μSv y^{-1}, who is most exposed to gaseous discharges (Table 13.5). This assessment outcome is for our proposed annual limits on discharges for the AP1000.

992 The highest doses are from gaseous discharges and the highest contribution was from carbon-14 in milk.

Table 13.5 Summary of our assessed doses to representative person at stage 3 from the AP1000 design at representative annual discharges and our proposed limits.

Pathway	Doses to the public μSv y^{-1}	
	Representative annual discharges	Our proposed limits
Liquid discharges	<1	<1
Gaseous discharges+	4	7
Direct radiation	4	4
Total dose	**8**	**11**

+ For the original design stack of 22.5m

993 It is noted that Westinghouse propose to increase the nuclear ventilation stack height from 22.5m to 40m. The increase is expected to be beneficial by increasing dispersion. This proposed design change involving increase in stack height has been taken into account in Westinghouse' second assessment. We will require the change in stack height to be considered at the site-specific stage.

13.5 Source dose constraint

994 There is a dose constraint (HMSO,2010[8])) 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.

995 As set out above, our assessment shows that, for the AP1000, the sum of doses to the representative person from representative annual discharges and direct radiation is 8 µSv y^{-1} and is below the source dose constraint. At our proposed limits, the sum of doses to the representative person is 11 µSv y^{-1},which is also below the source dose constraint.

996 **We conclude that the sum of doses to the representative person is below the source dose constraint.**

13.6 Site dose constraint

997 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.

998 All the sites listed in the Nuclear National Policy Statement (DECC 20011) as potentially suitable for a new nuclear power station are adjacent to existing nuclear power stations. In GDA, the specific site at which an AP1000 might be located is not known, but we consider, in the light of our assessment, that the highest total dose is estimated to be 11 µSv y^{-1} it is very unlikely that doses at the site will exceed the site dose constraint of 500 µSv y^{-1}. We consider that site dose should be assessed at the site-specific stage.

999 **We conclude that site dose should be assessed at site-specific permitting.**

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[8] The constraint was set under the Basic Safety Standards Direction (Defra, 2000) but the Direction was superseded by the Environmental Permitting Regulations 2010

13.7 Dose limit

1000 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 μSvy^{-1}) and it applies to the total dose from all artificial sources including past discharges, but excluding medical and accidental exposure.

1001 **Comparison against the dose limit can only be done at site-specific permitting when contributions from all sources of radiation can be included.**

13.8 Doses to people – collective dose

1002 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.

1003 The Health Protection Agency (GDA89) '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.

1004 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.

1005 The UK Health Protection Agency, Radiation Protection Division (HPA-RPD), 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-RPD advised that if the average per person doses for a population group are only a few nano-sieverts (nSv) 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.

1006 Westinghouse has provided information on collective dose.

1007 Westinghouse has estimated collective dose at the representative annual discharges to UK, Europe and world populations truncated at 500 years using PC CREAM 08. The atmospheric collective dose was assessed for the proposed revised effective stack height of 40m. Table 13.6 shows the results of Westinghouse's collective dose assessment.

Table 13.6 Collective doses estimated by Westinghouse from one year's discharges from AP1000 at representative annual discharges

Population	Collective dose manSv (per year of discharge)	Per person dose nSv (per year of discharge)
UK	0.23	4.2
Europe	1.5	2
World	8.8	0.9

1008 Westinghouse considers that the collective dose to all populations is dominated by releases of carbon-14 in gaseous radioactive waste.

1009 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 representative annual discharges of liquid and gaseous radioactive waste. We used the PC CREAM 98 software to estimate collective dose. Our results are set out in table 13.7 below.

Table 13.7 Our estimate of collective doses from one year's discharges from AP1000 at the representative annual discharges

Population	Collective dose manSv (per year of discharge)	Per person dose nSv (per year of discharge)
UK	0.26	4.7
Europe	2.1	2.8
World	13	1.2

1010 Comparing our assessment of collective dose and the assessment Westinghouse carried out before Westinghouse revised their assessment to account for an increased stack height shows almost identical results. Our assessment of collective dose similarly showed collective dose to be dominated by contributions from carbon-14 in discharges of gaseous radioactive waste.

1011 For comparison, the annual collective dose to the UK population from background radiation has been calculated as 130,000 person Sv (HPA, 2005). The collective dose from the AP1000 is above the IAEA level of 1 person Sv 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

1012 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.

1013 Westinghouse has provided information on assessment of doses to non-human species (ER Chapter 5.3). Its approach to assessing the impact on non-human species is summarised below:

a) Westinghouse predicted the expected discharges of radionuclides in aqueous and gaseous radioactive waste that are likely to occur from its AP1000 design. It has used this data to assess the potential impact of the discharges to non-human species.

b) In its assessment, Westinghouse 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, Westinghouse 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). Westinghouse has assumed that all reference organisms specified in ERICA are present and has included reference organisms that it considers are typical or representative of terrestrial and marine ecosystems.

1014 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).

1015 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 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.

1016 Westinghouse used the following parameters in its assessment:

a) The expected annual discharges of radionuclides to air and water were used to derive activity concentrations in sea water, sea bed sediments, air and soil using the IAEA SRS-19 model within the ERICA software code.

b) Default ERICA values for transfer parameters.

1017 The ERICA tool does not allow the consideration of the impact of radioactive noble gases that may be discharged. Westinghouse used the R&D 128 method (Environment Agency 2003) for the assessment of the impact of radioactive noble gases on non-human species.

1018 Westinghouse carried out its assessment of the impact of aerial releases on non-human species at tier 1 and its assessment of the impact of liquid releases at tiers 1 and 2. It considered the risk to terrestrial reference organisms from the predicted gaseous discharges and to marine reference organisms from the predicted liquid discharges.

1019 The results of the Westinghouse assessment:

a) identified that, for the most sensitive combination of reference organisms, the probability of the expected discharges exceeding the screening dose rate of 10 µGy h^{-1} is less than one per cent. (ER c5.3.1 section 5.3.1.1)

b) for marine organisms at tier 1, the dose rate for the most sensitive combination of reference organisms exceeded the screening dose rate, and therefore an assessment was carried out at tier 2. The results at tier 2 show that the predicted dose rates exceeded the screening dose rate of 10 µGy h^{-1} for the reference organisms polychaete worm, macroalgae, sea anemone/true coral polyp and colony, benthic mollusc, vascular plant, benthic fish and crustacean. The maximum predicted dose rate was 25.2 µGy h^{-1} for the polychaete worm. (ER c5.3.1 section 5.3.1.2)

c) The greatest radiological impact to non-human species from atmospheric discharges is from carbon-14. The radiological impact from marine discharges is generally greatest from iron-55 or iron-59, particularly for the reference organism that inhabit the sediment or sediment water interface.

1020 To assess the risks from noble gases, Westinghouse used the R&D 128 approach, using activity concentrations derived from the gaseous releases and the emission flow rate using the IAEA SRS-19 model. The assessment shows the highest total dose rate to fungi to be 0.00027 µGy h^{-1} which is well below the ERICA screening dose rate of 10 µGy h^{-1}.

1021 We carried out two evaluations of the assessment Westinghouse carried out using the ERICA tool and the R&D128.

a) A validation exercise to satisfy ourselves that the results of the Westinghouse assessment were reproducible.

b) An independent assessment at tier 2 to determine the dose rates using discharge data Westinghouse provided and predicted activity concentrations modelled for us by an independent contractor.

1022 We were able to reproduce the results of the assessment Westinghouse carried out using the ERICA model when we used its input parameters.

1023 Our 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 0.04 µGy h^{-1} for a mammal.

1024 We were able to reproduce the results of the assessment Westinghouse carried out using the R&D 128 approach when we used its input parameters.

1025 To assess the risks from noble gases, we used the R&D128 approach. We used our calculated predicted activity concentrations and calculated the highest predicted dose rate to be 0.00004μGy h^{-1} for a caterpillar which is well below the ERICA screening dose rate of 10 μGy h^{-1}.

1026 A summary of the outcomes of a comparison of the Westinghouse assessment with our assessments is set out below:

Assessment type	**Data source**	**Westinghouse results**	**Our results**
Terrestrial			
ERICA tier 1	Westinghouse	No risk for most sensitive combination of reference organisms	No risk for most sensitive combination of reference organisms
ERICA tier 2	Independent	-	No risk for any individual reference organism. Maximum predicted dose rate is 0.1 μGy h^{-1} for a bird egg
R&D 128	Westinghouse	Maximum predicted dose rate is 0.00027 μGy h^{-1} for fungi	Maximum predicted dose rate is 0.0003 μGy h^{-1} for fungi
	Independent	-	Maximum predicted dose rate is 0.00004 μGy h^{-1} for caterpillar
Marine			
ERICA tier 1	Westinghouse	Maximum predicted dose rate for most sensitive combination of reference organisms is greater than 10 μGy h^{-1}	Maximum predicted dose rate for most sensitive combination of reference organisms is greater than 10 μGy h^{-1}
ERICA tier 2	Westinghouse	The predicted dose rates exceed the screening value of 10 μGy h^{-1} for 9 reference organisms. The maximum predicted dose rate is 25 μGy h^{-1} for polychaete worm	The predicted dose rates exceed the screening value of 10 μGy h^{-1} for 9 reference organisms. The maximum predicted dose rate is 25 μGy h^{-1} for polychaete worm
	Independent	-	No risk for any individual reference organism. Maximum predicted dose rate is 0.04 μGy h^{-1} for a mammal

*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.

1027 There is some variation between the results obtained using the predicted activity concentrations Westinghouse provided and those by our independent contractor.

1028 For the marine assessment, the results predicted using our data are significantly lower than those using the Westinghouse input data. This is because in its assessment Westinghouse used discharge rates that were converted into activity concentrations using the IAEA SRS 19 methodology. In our assessment we used activity concentrations derived using PC CREAM. The SRS 19 method is a more conservative approach, and, therefore, overestimates the activity concentrations in water and sediment.

1029 The results of the terrestrial assessments are different because they were carried out at different tiers of the ERICA tool. However, the results using both the Westinghouse input data and our data are two or more orders of magnitude lower than the screening dose rate. The results of the assessments using the R&D128 approach were not significantly different.

1030 We conclude that the assessment Westinghouse carried is conservative and reasonable at the GDA stage, and we conclude that Westinghouse has used an appropriate approach to assessing the radiological impact of the AP1000 on non-human species.

1031 We note, however, that the marine tier 2 results exceed the screening dose rate of 10 µGy h^{-1}, but they do not exceed the dose limit of 40 µGy h^{-1} that we have agreed with Natural England in order to protect Natura 2000 sites. The results of our assessments do not exceed the screening dose rate.

1032 **We conclude that at the GDA stage we consider that the maximum predicted gaseous releases and liquid discharges for an AP1000 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 AP1000 will be required for any site where the AP1000 is proposed.**

1033 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/hand 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*'

1034 We provide some additional explanation of our methodology below:

Dose rate comparison

1035 As part of non-human assessments we compare predicted dose rates to a screening value of 10µGyh^{-1} (different to µSvh^{-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 10µGyh^{-1} we do not require further assessments to be made. It was proposed by an European consortium of experts called PROTECT (Andersson 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).

1036 We use an action level of 40µGyh^{-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 $100\mu Gyh^{-1}$; and

b) a review paper (Brown et al., 2004) which indicated that wildlife might receive up to $60\mu Gyh^{-1}$ from natural sources in European ecosystems.

1037 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 $10\mu Gyh^{-1}$ 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 $40\mu Gyh^{-1}$ 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.

1038 Westinghouse's predicted dose rates for the AP1000 generic design discharges to the marine environment did exceed the $10\mu Gyh^{-1}$ screening level for some organisms. Therefore a more detailed assessment was completed where the predicted dose rates were compared to the $40\mu Gyh^{-1}$ action level, and the radionuclides contributing to higher dose rates considered.

1039 We will conduct more refined assessments for the site-specific applications.

Confidence in the assessment methodology

1040 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.

1041 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.

1042 We are participating in model intercomparison 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).

1043 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

1044 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.

1045 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

1046 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.

1047 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 μGyh^{-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.

1048 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.

1049 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 environment regulations

14.1 Water Resources Act 1991 (as amended): Water abstraction

14.1.1 Conclusion

1050 Our conclusions have been updated since our consultation to reflect the concerns of respondents about damage to marine life at seawater intakes.

1051 **We conclude that:**

a) **The Westinghouse 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 sea water intake to minimise damage to marine life will be a site-specific issue.**

1052 Our conclusions refer to the Westinghouse 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

1053 Westinghouse says that the AP1000 will need supplies of freshwater for several purposes and assume for GDA that this will be from a mains supply (ERs2.7):

a) for the demineralised water treatment plant that provides treated water for the primary and secondary circuits;

b) to provide potable water for drinking and sanitation needs (showers and lavatories);

c) to supply the fire protection system.

1054 Westinghouse provides normal and maximum flows for each use in ER Figure 2.7-1, that is up to 100 $m^3\ h^{-1}$ in normal operation.

1055 Providing freshwater will be a site-specific issue, and we have not considered this at GDA. If a site needs abstracted surface water or groundwater, then the operator will need to obtain an abstraction licence (under the Water Resources Act 1991) from us before any abstraction takes place.

1056 Westinghouse only considers a coastal site at GDA and assumes cooling water requirements will be met by abstraction of seawater. 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 (EN-6)

(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*'.

1057 The AP1000 has two cooling systems:

a) the circulating water system (CWS) (ERs2.7.1) supplies seawater to remove heat from the:

   i) main condensers;

   ii) the turbine building closed cooling water system (TCS) heat exchangers;

   iii) the condenser vacuum pump seal water heat exchangers;

b) the service water system (SWS) (ERs2.7.2) supplies seawater to remove heat from the component cooling water system (CCS) heat exchangers in the turbine building.

1058 Westinghouse predicts the following flows and return temperatures (ERs4.2.3.3):

a) CWS: 38 $m^3 s^{-1}$ at 14°C warmer than intake;

b) SWS: 1.3 $m^3 s^{-1}$ at 18.3°C warmer than intake.

1059 The returning flows are combined at the seawater return sump where the temperature will be 14.15°C warmer than intake.

1060 The SWS is a seawater system for the GDA generic site (a coastal site). The European DCD and the PCSR describe an option to use a cooling tower system where seawater cooling is not practical. A cooling tower system would need additional fresh water supplies at up to 182 $m^3 h^{-1}$. (ERs7.2)

1061 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. Potential operators will need to contact us for advice, giving full details of their proposals.

1062 The abstracted seawater will need to be filtered to remove debris, including seaweed before it is used. Westinghouse has not provided information on this topic at GDA. Handling the removed material will need to be considered for each site, as it will be a waste for disposal. In some cases, it can be macerated and returned to the sea. The 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.

1063 One individual respondent (GDA167) was concerned that no information on intake filtering was provided but accepts this is a matter to determine at specific sites.

1064 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.

1065 There were fourteen responses about this topic and most agreed with our conclusion that abstraction from the open sea would not require an abstraction licence.

1066 However, most respondents, in particular Seafish (GDA91), Stop Hinkley (GDA157) and West Somerset Council and Sedgemoor District Council (GDA155) 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, this would be covered under Environmental Impact Assessment within planning controls. We seek to influence operators at the early stage of projects (our report '*Cooling Water Options*' mentioned above) and through the planning process.

1067 Blackwater against New Nuclear Group (GDA113) and the Countryside Council for Wales (GDA144) were concerned we did not consider estuarial locations at GDA. The generic site defined by Westinghouse did not include estuaries and so they are not considered in GDA. We agree with the respondents 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.

1068 A future operator Horizon Nuclear Power (GDA128), undertook to ensure that intake design on their sites would be designed to minimise impact on the local marine environment.

1069 The Countryside Council for Wales (GDA144) 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 Westinghouse, 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.

14.2 Environmental Permitting Regulations 2010 (EPR 10): Discharges to surface water

14.2.1 Conclusion

1070 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 15.2.2 and include the outcome within conclusion a) below.

1071 **We conclude that:**

a) **the predicted discharges of non-radioactive substances from an AP1000 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 an AP1000 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

1072 We have assessed (within the constraints imposed by the generic site) whether discharges to water from the AP1000 could pose an unacceptable risk to the environment.

1073 The underlying objective of our detailed assessment is to determine whether we could grant a water discharge permit for the AP1000 design, subject to any matters that can only be dealt with at the site-specific stage.

1074 We received twelve 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 (GDA39). This will be a future operator decision, we expect justification of biocides proposed to be provided with site-specific applications.

b) GDA39 - 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 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) Ingleby Barwick Town Council (GDA39) suggested that the outlet design should be able to mitigate the heat impact. We agree and expect to see future Operators applying BAT to outlet designs.

e) In particular Seafish (GDA91) 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.

f) Effluent from conventional drains or sanitation systems is not covered (Maldon Town Council GDA59). 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.

g) The Health Protection Agency (GDA89) says that we should expand the range of contaminants assessed for impact on health. We have advised potential operators that they will need to provide more detailed information in applications for site discharge permits, in particular for trace metals.

h) There was a query at our stakeholder event about boron discharges. There will be boron discharged from the AP1000 but the impact is shown below as 0.02 % of the environmental quality standard.

1075 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).

1076 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.

1077 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.

1078 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 AP1000 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.

1079 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.

1080 At GDA it is not possible to assess the AP1000 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.

1081 Westinghouse has carried out a generic impact assessment of direct (or once-through) cooling, in terms of water quality and ecology. This is useful as it demonstrates an awareness of the relevant issues, highlights potential impacts and identifies mitigation measures. However, as the assessment is based on a generic UK site, the conclusions can only be qualified through further site-specific work. Westinghouse has identified the need for such work to properly assess potential impacts, particularly those relating to habitats and species.

1082 Westinghouse says that the AP1000 will generate the following liquid effluents:

a) effluent from the liquid radwaste system (WLS)(ERs3.4.3). The radioactivity of this effluent is dealt with in our 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) effluent from the wastewater system (WWS) that serves the drains in the non-radioactive building areas of the AP1000. The effluent is collected in sumps and then pumped through an oil separator to the wastewater retention basin for settling of suspended solids and treatment, if required. The basin is discharged, after sampling and appropriate discharge approval, to the seawater return sump through release point W11, (ERs4.2.1.1 and ER Figure 6.2-2);

c) effluent from the sanitary drainage system that serves rest rooms and locker room facilities in non-radiologically controlled areas. The system design will be site-specific and has not been assessed at GDA.

1083 The following systems also discharge into the wastewater system (WWS):

a) the demineralised water treatment system treats raw water using filters, reverse osmosis and electro-deionisation. Chemicals are added in trace quantities to adjust pH and to act as an anti-scalant. The reject flow from reverse osmosis is sent to the WWS (ERs4.2.2.1);

b) the steam generator blowdown system takes a blowdown from each steam generator and treats it to reduce impurities (normally non-radioactive particles that cannot be allowed to build up in the boiler water). Blowdown is normally recycled into the secondary system but, in event of high impurity levels, can be discharged to the WWS (ERs4.2.2.2). If significant radioactivity is detected in the secondary side systems, blowdown is re-directed to the liquid radwaste system;

c) the condensate system provides feedwater to the secondary system. An ion exchange bed is used to polish the feedwater at start-up, the bed is rinsed before use and the rinse water sent to the WWS (ERs4.2.2.3).

1084 The main chemicals used in the AP1000 and associated with the liquid radioactive effluent are (ERs2.9.1 and s4.2):

a) boric acid used as a neutron absorber and added to:

   i) the coolant (concentration from 612 to 2700 ppm);

   ii) the spent fuel pool and fuel transfer canal;

   iii) the in-containment refuelling water storage tank / refuelling cavity;

   iv) the cask wash-down pit.

1085 (Concentrations for ii, iii and iv are all 2700 ppm)

a) lithium hydroxide added to the coolant to offset the acidity of the boric acid to prevent equipment corrosion;

b) hydrazine used as an oxygen scavenger in the feedwater at start-up;

c) zinc acetate added to the coolant to be incorporated into oxide films on wetted reactor components to reduce corrosion;

d) trace metals such as iron, nickel, copper and chromium from corrosion and erosion where coolant and other process waters contact equipment. Westinghouse was unable to provide predictions for quantities of these at GDA. However, effluents are filtered and, in the case of effluent from treating coolant, passed through ion exchange resins. These techniques will minimise the quantities of metals present in discharges.

1086 Westinghouse lists other chemicals used in the AP1000 and not associated with the radioactive effluent in ER table 2.9-1. Chemicals include ammonium hydroxide, used for pH control; ammonium chloride, used as an algaecide; sodium hypochlorite, used as a biocide; and polyphosphate, used as an anti-scalant.

1087 Seawater cooling circuits need to be protected from biological fouling when the seawater inlet temperature is above 10°C, assumed to be for six months of the year. The AP1000 will use sodium hypochlorite as a biocide (30 per cent solution from an 11.4 tonne tank). The system will leave residual oxidants, chlorine and halogenated by-products such as bromoform in the returning seawater. (ERs4.2.5.1)

1088 Westinghouse claims the use of sodium hypochlorite will be minimised by using BAT in the design of the cooling system. ER Table 4.2-3 provides a list of techniques to be considered. Many of these relate to site-specific conditions or operator procedures and, therefore, we could not readily assess for GDA, but they will be important concerns for site-specific permitting.

1089 Westinghouse has provided an estimate of the impact of biocide dosing on the receiving environment, quantifying the likely concentration of total residual chlorine against its respective EQS. While Westinghouse concludes that the predicted discharge will exceed the EQS at the point of discharge, it expects the concentration to decrease rapidly upon mixing with seawater. It says that there is minimal risk that the EQS would be exceeded at the edge of the mixing zone, but site-specific monitoring would be necessary to prove this. It acknowledges that the required dosing regime is highly site-specific and depends on local water quality conditions. This is why we have not assessed this matter GDA. Future work involving using local water quality information and dispersion modelling of each discharge would be necessary to support a site-specific application for a water discharge permit.

1090 Suspended solids may come from dirt collected in drain effluents. The waste water retention basin allows for settling of suspended solids before discharge. (ERs4.2.1.1)

1091 Westinghouse has not provided information on chemical oxygen demand (COD) in effluents from the AP1000 at GDA. An operator will need to provide this information to complete a site-specific permit application.

1092 Liquid effluents are collected for monitoring before discharge into the seawater sump, where there is immediate and substantial dilution provided by the flow of returning cooling water, approximately 39 $m^3 s^{-1}$. The two main effluent streams, from the liquid radwaste system and the wastewater system, discharge as follows:

a) radioactive effluents are collected in the six monitor tanks of the liquid radwaste system and discharged through point W7, a pumped discharge with a design flow rate of 22.7 $m^3 h^{-1}$;

b) non-radioactive effluents from the waste water system are collected in the wastewater retention basin and are discharged through point W11 at a maximum design flow rate of 408 $m^3 h^{-1}$.

1093 We assume the flow monitoring and sampling equipment at points W7 and W11 will be used for both radioactive and non-radioactive discharge measurements.

1094 Westinghouse has provided an impact assessment for some of the substances discharged to sea from the AP1000. It has estimated annual discharges of chemicals and calculated discharge concentrations based on dilution in the annual flow of seawater cooling (1.24 x 109 m^3), ER Table 4.2-2:

Chemical	**Quantity (kg y^{-1})**	**Annual average concentration (AAC)(μg l^{-1})**	**Environmental quality standard (EQS)(μg l^{-1})**	**AAC/EQS (%)**
Boric acid (as boron)	≤7884 ≤(1380)	1.1 (as boron)	7000	0.02
Lithium hydroxide	6.4	0.005	-	-
Zinc acetate	<1.2	<3.4 x 10-5 (as Zinc)	40	0.00009
Trace metals in chemicals	3.3 (based on 1 ppm)	0.0027	lowest EQS is mercury at 0.3	0.9
Sodium hypochlorite	< 121490	< 200	10 (TRO)	-
Ammonium chloride/hydroxide	< 35,670	< 11 (ammonia as N)	21 (our proposed EAL for unionised ammonia as N)	-
Hydrazine	370	0.3	-	-

Notes: Westinghouse conclude that the predicted discharge will exceed the EQS for TRO at the point of discharge to the sea, but that there is minimal risk that the EQS would be exceeded at the edge of the mixing zone. As the fate of chlorine in seawater is a highly complex issue further site-specific studies will be required in this area.

1095 Westinghouse assumed a worst case of 1 ppm metal contamination of bulk chemicals used to predict the discharge concentration of trace metals. The predicted discharge concentration is less than 1 per cent of the lowest EQS (mercury). We do not consider substances with discharge concentrations at less than 1 per cent EQS to be significant, and do not require detailed dispersion modelling or further impact assessment. This follows the screening principles set out in our H1 assessment guidance (Environment Agency, 2010e). H1 is used for assessing the risks to the environment and human health from facilities which 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.

1096 Ingleby Barwick Town Council (GDA39) thought that the '*mercury level should not be dismissed lightly*'. We agree, we expect future operators to provide us with better information having sourced their supply of bulk chemicals with lowest contamination levels.

1097 As mentioned above, Westinghouse does not predict levels of corrosion products such as iron, nickel, copper and chromium that will be expected in trace quantities in the radioactive effluent.

1098 An operator will need to provide more accurate predictions of all metals liable to be contained in the liquid effluents to complete a site-specific permit application. This should include details of corrosion products arising from both the primary and secondary circuits and impurities within bulk raw materials.

1099 We have commissioned 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'* (Science Report SC090012/SR). The report will be ready to support our site-specific permitting work.

1100 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.

1101 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.

1102 As mentioned above, more detailed information on dangerous and priority substances, particularly metals, would be required in support of a site-specific permit application.

1103 Westinghouse claims that the return temperature of seawater used for cooling will be 14.15°C warmer than at intake. It has provided no information on impact, stating that a site-specific definition of mixing zone and impact evaluation will be required. 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 in support of site-specific application for a discharge permit.

1104 Westinghouse claims that the wastewater retention basin has enough volume to retain any unplanned emissions of effluents or spillages. Effluents that cannot be discharged can then be treated or disposed of off-site (ERs4.2.6.1). Westinghouse states that the design of the wastewater retention basin is a site-specific matter and has not provided any detailed information. We have, therefore, not been able to assess this aspect at GDA. The operator will be required to submit the design details, including justification of retention volume, to support a site-specific permit application.

1105 Westinghouse says that storm water falling on the site of an AP1000 will be collected into a storm water pond. The storm water system will need to incorporate an oil separator to cope with any oil spillage on roads or loading areas. The detailed design will be site-specific and has not been assessed at GDA.

1106 Westinghouse says that fire water from internal fire fighting would be initially retained within buildings. Fire water used externally should be collected in the storm water pond. In both cases, fire water can be treated or disposed of off-site and should not be discharged in an uncontrolled way.

1107 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 AP1000 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 Westinghouse submitted, we believe, in principle and without prejudice to our formal determination of an application in due course, that we should be able to issue a permit to discharge liquid effluents from the AP1000 reactor to the sea.

1108 A future operator, Horizon (GDA128), 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*'.

1109 West Somerset Council and Sedgemoor District Council (GDA154) 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 [GDA154 was a response applicable to both designs but with main reference to the UK EPR design*]. 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 (EPR 10): Discharges to groundwater

14.3.1 Conclusion

1110 Our conclusions remain unchanged since our consultation.

1111 **We conclude that:**

a) **the site of an AP1000 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 AP1000 are adequate to prevent any leaks or spills entering groundwater.**

14.3.2 Background

1112 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.

1113 Westinghouse claims that there are no direct or indirect discharges to groundwater from the AP1000 (ERs4.2.1). In that case, an AP1000 should not need to be permitted by us for a discharge to groundwater under EPR 10.

1114 Seven 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 (GDA89) in particular supported use of the borehole network to monitor for a range of non-radioactive substances.

1115 Westinghouse lists the following relevant substances as liable to be on an AP1000 site (ER Table 2.9-3/4):

a) hazardous substances: hydrazine, halogenated by-products of chlorination of seawater (for example, bromoform), hydrocarbons (fuel oil) and radioactive substances;

b) non-hazardous pollutants: sodium hypochlorite, metals, phosphates and ammonium hydroxide.

1116 Ingleby Barwick Town Council (GDA39) question the use of 'non-hazardous pollutant' for sodium hypochlorite, it should not be regarded as a comment on hazard as generally understood. This is a term used by the Groundwater Directives as another category to 'hazardous'. ' Hazardous' substances are especially toxic and persistent in terms of groundwater.

1117 Diesel fuel (a hydrocarbon) used by the AP1000 stand-by generators will present a potential risk to groundwater. We will make sure that storage of fuel complies with the Control of Pollution (Oil Storage) (England) Regulations 2001 and confirm, by inspection during construction, that any oil handling facilities will prevent any oil leaks or spills reaching groundwater.

1118 Ingleby Barwick Town Council (GDA39) reminds that '*diesel fuel needs to be bunded – not forgetting the filling hose and nozzle*'. We confirm that the Oil Storage Regulations cover these issues and we will inspect compliance before any diesel is stored.

1119 Westinghouse claims that all AP1000 chemical storage tanks will be provided with secondary containment (bunds) (ERs2.9.4). Details of the secondary containment are provided in the ER Table 2.9-6. We note that some containment issues are deferred until the site-specific design stage.

1120 The borehole network discussed in section 8.3 of this document (for monitoring of radioactive contamination) should also be used to monitor for a range of non-radioactive substances to be agreed at the site-specific stage.

14.4 Environmental Permitting Regulations 2010 (EPR 10): Combustion plants

14.4.1 Conclusion

1121 Our conclusions remain unchanged since our consultation.

1122 **We conclude that the AP1000 does not include any installations that contain activities described in Part 2 of Schedule 1 of EPR 10.**

14.4.2 Background

1123 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 AP1000, combustion activities are relevant:

a) in Part A(1)(a) – where fuel is burned in two or more appliances with an aggregated rated thermal input of 50 MW or more; or

b) in Part B(a) – burning any fuel in a compression ignition engine, with a rated thermal input of 20 or more megawatts, but a rated thermal input of less then 50 MW.

1124 The AP1000 will have two stand-by diesel generators each providing 4 MW of electricity. Westinghouse states that the maximum rated thermal input of each will be 12.9 MW. The aggregate of the two units is therefore 25.8 MW – below the threshold for a Part A EPR activity. Further, the individual units are less than 20 MW and will not fall into Part B. The operator for a single AP1000 site (the GDA case) will not require an EPR 10 permit for the diesel generators. If more than one AP1000 were to be proposed for one location, the operator will need to discuss with us the implications for EPR 10 permitting. (ERs4.1.1.2)

1125 The diesel generators will require a supply of fuel. The fuel oil storage tank facility of capacity 454 m^3 will need to comply with the Control of Pollution (Oil Storage) (England) Regulations 2001.

1126 Nine respondents generally agreed with our conclusion.

1127 Ingleby Barwick Town council (GDA39) noted that if more than one plant is installed at one site the conclusion may change. We agree but it is a matter for site-specific permitting, also any auxiliary combustion equipment such as boilers would need to be counted to see if EPR 10 applies.

14.5 Environmental Permitting Regulations 2010 (EPR 10): Waste management

14.5.1 Conclusions

1128 Our conclusions are unchanged since our consultation, however, we have removed other issue (AP1000-OI09) on construction waste that was in our Consultation Document as this issue is covered by the Site Waste Management Plans Regulation 2008.

1129 **We conclude that Westinghouse'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.**

1130 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

1131 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 Westinghouse'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).

1132 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.

1133 We summarise below the information presented in Westinghouse'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

1134 Westinghouse's integrated waste strategy (IWS) document outlines its current strategy for managing radioactive and non-radioactive waste produced over the whole lifecycle of the site, including operational and decommissioning activities. The IWS does not include waste from construction activities.

1135 Westinghouse states in its IWS that the requirements of the waste management hierarchy are inherent in many aspects of the AP1000 design.

1136 Westinghouse's IWS states that the site's integrated management system will address the following:

a) control of activities to prevent and minimise waste arisings;

b) control of waste management activities, which include waste classification and segregation and application of the waste hierarchy;

c) maintain arrangements and equipment required to: minimise waste arising, management of waste, and monitoring and sentencing of waste;

d) check the effectiveness of arrangements and equipment required to: minimise waste arising, management of waste, and monitoring and sentencing of waste;

e) sharing and using good practice across waste streams and projects on the site;

f) sharing and using good practice with other sites;

g) identifying research and technology requirements relating to waste management;

h) identifying competence and skills requirements relating to waste management;

i) managing records and information;

j) managing interfaces with other sites.

1137 Westinghouse states in its IWS that the expected volumes of conventional solid waste generated will benefit from good management arrangements together with the features inherent in the AP1000. It says that these features, when combined with best industry practice operating regimes, lead to a reduction in the volumes of conventional waste generated. Westinghouse's strategy for conventional waste arisings is that they are collected and sorted on-site before being transported to appropriate permitted facilities for recovery or disposal.

1138 The sources of non-radioactive solid waste are summarised in Table 4.3-1 of the ER. A schematic showing the proposed treatment and disposal of non-radioactive waste is shown in Figure 4.3-1 of the ER.

1139 An individual respondent (GDA26) 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.

1140 Ingleby Barwick Town Council (GDA39) provided the following response: '*It should be remember that one man's waste is sometimes another man's feedstock, so 'waste' needs to be managed for everyone's benefit.'* We agree that reuse and recycling of materials and wastes should be considered, in accordance with the waste hierarchy.

1141 The Health Protection Agency (GDA89) provided the following response: '*The Health Protection Agency notes the EA's proposal to include waste from construction activities in the waste strategy for each site at the site-specific permitting stage. However, in order to do this the EA should ensure that construction does not take place before the permitting process has started. If it is not possible to unilaterally impose this then this aspect may instead need to be addressed through planning controls*.' We have considered this response and therefore, we have removed our assessment finding (from our preliminary conclusion in our consultation document) on this matter. We note that under the provisions of the Site Waste Management Plans Regulation 2008, the future operator shall produce a Waste Management Plan for construction projects with an estimated cost greater than £300,000.

1142 Maldon Town Council (GDA59) provided the following response on construction waste: '*We agree with conclusion and note that waste strategy during construction is not mentioned'*. The Springfields Site Stakeholder Group (GDA97) 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*.' The Nuclear Technology Subject Group of the Institution of Chemical Engineers (GDA71) and the Institution of Mechanical Engineers (GDA146) also provided similar responses. As mentioned above, we no longer have an assessment finding on this matter because this is covered by the Site Waste Management Plans Regulation 2008.

1143 West Somerset Council and Sedgemoor District Council (GDA155) 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 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.

1144 Horizon Nuclear Power (GDA128) who is a potential future operator of the AP1000 responded saying that it welcomed our conclusions.

1145 Westinghouse UK (GDA110) said it agrees with our preliminary conclusions and that it is committed to resolving any outstanding issues within the GDA process.

14.6 Control of Major Accident Hazards Regulations 1999 (COMAH)

14.6.1 Conclusions

1146 Our conclusions remain unchanged since our consultation.

1147 **We conclude that:**

a) **the AP1000 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 Westinghouse qualitative assessment that a major accident to the environment involving hydrazine is highly unlikely is reasonable. The operator will need to provide 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 an AP1000 installation.**

1148 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

1149 Westinghouse estimated the quantities of chemicals potentially to be stored on the site of an AP1000 and compared this with the qualifying quantities of named dangerous substances to which COMAH applies (COMAH (Amendment) Regulations 2005). The most significant chemicals are shown below (from ER Tables 2.9-1/2):

Chemical	Stored quantity (te)	Lower tier threshold (te)	Upper tier threshold (te)
Hydrazine (35% solution)	1.1 (as hydrate)	0.5	2
Hydrogen	0.8	5	50
Petroleum spirits (diesel for back-up generators)	467	2,500	25,000

1150 Westinghouse, therefore, states that the site of an AP1000 will become a COMAH lower tier installation because of the expected storage quantity of more than 0.5 tonne of hydrazine hydrate. (ERs2.9.2.1)

1151 Several respondents agreed with the designation of an AP1000 as a COMAH lower tier installation.

1152 One respondent (GDA39) 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.

1153 The Health Protection Agency (GDA89) queried whether all chemicals stored, which fall under the COMAH Regulations had been considered. Westinghouse did provide some information on the hazardous chemicals stored in the AP1000 (ER Tables 2.9-1/2). 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.

1154 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 will be site-specific issues for the operator, and we have not considered this at GDA – our main purpose at GDA was to find out if COMAH would apply.

1155 Westinghouse claims that other substances listed in ER Tables 2.9-1/2 are either not hazardous or not stored in sufficient quantity to be considered under COMAH.

1156 Hydrazine is used in small quantities as an additive to water in the secondary circuit to consume residual oxygen. Hydrazine is a named carcinogen in the COMAH Regulations – hence the low threshold values – and its main risk is to the workforce.

1157 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.

1158 Westinghouse claims that the following preventative measures will be effective in preventing the accidental pollution of the marine environment with hydrazine (ERs5.4.5):

a) primary containment in steel tank or tote container in turbine hall;
b) secondary containment provided by chemical area containment dyke in turbine hall;
c) spill collection in turbine hall sumps;
d) final barrier is retention in the waste water retention basin;
e) external spills controlled by temporary spill barriers;
f) manual intervention to neutralise spills.

1159 Westinghouse claims the above measures make it unlikely that the whole stored quantity of hydrazine (1.1 te) will reach the sea. If hydrazine does enter the sea, then deoxygenation will be the most significant effect. However, Westinghouse believes this would be of a minor, limited spatial extent, for a short duration and local to the release point (ERs5.4.4). We agree with this qualitative risk assessment at this time for GDA. It would appear that a major accident to the environment is highly unlikely from an accident involving hydrazine stored on the AP1000. The operator will need to have a more detailed risk assessment available before site operations commence.

14.7 EU Emissions Trading Scheme

1160 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.

1161 An AP1000 will have 25.8 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

1162 We have issued an interim statement of design acceptability (iSoDA) for the AP1000. This is reproduced at Annex 1. It is valid only, where relevant, for a site meeting the identified generic site characteristics (see section 13.3 above).

1163 We made our decision to issue an iSoDA after we had carefully considered all relevant responses to our consultation.

1164 **We are issuing an interim SoDA at this time because we have two GDA Issues:**

a) **Westinghouse to submit a safety case to support the GDA Design Reference and then to control, maintain and develop the GDA submission documentation, including the SSER, the MSL 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.(GI-AP1000-CC-02 REVISION 3)**

b) **Westinghouse 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. (GI-AP1000-CC-03 REVISION 2)**

1165 Westinghouse has proposed Resolution Plans to address both GDA Issues available on the Regulators joint website (see http://www.hse.gov.uk/newreactors/2011-gda-issues-ap1000.htm) With ONR, we have reviewed these plans, and consider them credible.

1166 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.

1167 Chapter 16 in the Consultation Document was our 'Conclusion' and we asked for views on this. Ten respondents generally supported our overall conclusion. Several were confident that the three GDA Issues we had at consultation could be resolved, and these were indeed closed out by additional information as shown earlier in this document.

1168 The Health Protection Agency (GDA89) 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*'.

1169 The Greater Manchester Socialist Environment Resources Association (GDA125) provided comment in regard to the EPR design, and the comments raised are considered applicable to AP1000;

a) *'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 EPR consultation document) 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'.*

1170 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.

1171 We closed out the potential GDA Issues discussed in our consultation on decommissioning, see section 7.3, 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.

1172 We also closed out the potential GDA issues discussed in our consultation on nuclear ventilation, and disposability of spent fuel see sections 8.4.3 and 12.4.7 respectively.

1173 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. 63 responses to question 17 can be seen in our summary report of responses at https://consult.environment-agency.gov.uk/portal/ho/nuclear/gda

1174 We are pleased that several respondents supported our assessment '*we agree overall preliminary comments and acceptability of designs submitted*' (GDA 59) '*very thorough, well-prepared and highly professional report'* (GDA85) and '*thorough and robust'* (GDA71). Overall responses were generally favourable to the GDA process.

1175 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. Others wished to express their support for a particular design in GDA. We only consider in GDA whether a design can meet UK regulatory requirements so comments from these respondents were considered to be outside our assessment area. The Government has issued '*Meeting the Energy Challenge: A White Paper on Nuclear Power*' (BERR, 2008a).

1176 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.

1177 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

AP1000®	AP1000 is trademark of Westinghouse Electric Company LLC.
AGR	Advanced gas-cooled reactor
BAT	Best available techniques
BWR	Boiling Water Reactor
C&I	Control and Instrumentation
COMAH	Control of Major Accident Hazards Regulations 1999
CVS	Chemical and volume control system
CWS	Circulating water system
DAC	Design Acceptance Confirmation (by ONR)
DCD	Design Control Document
DCP	Design change proposal
DECC	Department of Energy and Climate Change
EA 95	Environment Act 1995
ENSREG	European Nuclear Safety Regulatory Group
EPA 90	Environmental Protection Act 1990
EPR 10	Environmental Permitting (England and Wales) Regulations 2010
EQS	Environmental Quality Standard
ER	UK AP1000 Environment Report
ERs*.*	Environment Report section reference e.g. 3.2.2.2
FAPs	Fission and Activation Products
GALE	Gaseous and liquid effluents – code for the calculation of radioactive materials in gaseous and liquid effluents from pressurised water reactors used by the United States Nuclear Regulatory Commission
GDA	Generic Design Assessment
HEPA	High efficiency particulate air (filter)
HLW	High level waste
HPA-RPD	Health Protection Agency – Radiation Protection Division
HSE	Health & 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	Integrated Waste Strategy
JPO	Joint Programme Office
LLW	Low level waste
LoC	Letter of Compliance
MSL	Master Submission List
NDA	Nuclear Decommissioning Authority
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)
ORE	Occupational radiation exposure
PCSR	Pre-Construction Safety Report
PWR	Pressurised Water Reactor
QA	Quality Assurance
QMS	Quality Management System
QNL	Quarterly Notification Level
RCCA	Rod Cluster Control Assemblies
RCS	Reactor coolant system
REPs	Radioactive substances regulation environmental principles
RI	Regulatory Issue
RO	Regulatory Observation
RSA93	Radioactive Substances Act 1993
RWMD	Radioactive Waste Management Directorate (of NDA)
SBO	Station black out
SG	Steam generator
SoDA	Statement of Design Acceptability
SSER	Safety, Security and Environment Report
SWS	Service water system
TQ	Technical Query
US NRC	United States Nuclear Regulatory Commission
VFS	Containment air filtration system
VTS	Turbine building ventilation system
WCPD	Worst case plant discharge
WEC	Westinghouse Electric Company LLC
WGS	Gaseous radioactive waste system
WLS	Liquid radioactive waste system
WRA91	Water Resources Act 1991

WWRB	Wastewater retention basin
WWS	Wastewater system

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.

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 (manSv): 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™, 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 AP1000® design submitted by Westinghouse Electric Company LLC

(Westinghouse)

The Environment Agency has undertaken a Generic Design Assessment of the Westinghouse UK AP1000® 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 Westinghouse's UK AP1000[2].

The Environment Agency is satisfied that Westinghouse has demonstrated the acceptability for environmental permitting of the AP1000 on the generic site, as defined in Schedule 1, subject to the GDA issues identified in Schedule 2.

This statement is provided as advice to Westinghouse, under section 37 of the Environment Act 1995. It does not guarantee that any site-specific applications for environmental permits for the AP1000 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 Westinghouse's AP1000®, Environment Agency, December 2011.

Schedule 1 – Scope of the GDA

This interim statement of design acceptability refers to the AP1000 design as described in the design reference documentation:

a) *AP1000 Design Reference Point for UK GDA Reference date: 16 September 2010.* UKP-GW-GL-060 Revision 5. 1 November 2011. Westinghouse Electric Company LLC.

b) *AP1000 Environment Report*. UKP-GW-GL-790 Revision 4. Westinghouse Electric Company LLC.

c) The documents contained in the *Master Submission List: Maintaining the Configuration of the United Kingdom Generic Design Assessment of the European AP1000 Design, 2007-2011*. UKP-GW-GLX-001 Revision 1. Dated 1 October 2011. Westinghouse Electric Company LLC.

Certain aspects have been agreed as being out of scope for GDA and these are defined by Westinghouse in its letter WEC00728 GDA, Out of Scope Items, dated 7 November 2011.

Schedule 2 – GDA Issues

WESTINGHOUSE AP1000® GENERIC DESIGN ASSESSMENT

GDA ISSUE

PCSR TO SUPPORT GDA

GI-AP1000-CC-02 REVISION 3

Technical Area	**CROSS CUTTING**		
Related Technical Areas	**None**		
GDA Issue Reference	**GI-AP1000-CC-02**	**GDA Issue Action Reference**	**GI-AP1000-CC-02.A1**
GDA Issue	**Westinghouse to submit a safety case to support the GDA Design Reference and then to control, maintain and develop the GDA submission documentation, including the Safety, Security and Environment Report (SSER), the Master Submission List (MSL) 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 the Environment Agency (the joint Regulators) may issue at the end of GDA.** **This GDA Issue is raised by both the ONR and Environment Agency**		
GDA Issue Action	Westinghouse to submit to the joint Regulators a consolidated Pre-Construction Safety Report (PCSR) and associated references which provides the necessary claims, arguments and evidence to substantiate the adequacy of the AP1000 described by Design Reference Point (DRP) UKP-GW-GL-060 revision 2 and make available via the Westinghouse Website a public version of the consolidated PCSR, the Design Reference Document and the Master Submission List. Westinghouse is required to carry out a review and reassessment of their PCSR. This review should cover: • PCSR UKP-GW-GL-793 Revision 0. • Weaknesses identified with the PCSR UKP-GW-GL-732 Revision 2. • Alignment of the DRP and MSL with the PCSR and associated references and ensure there is no adverse affect on impacted documents from the Design Change Proposals (DCPs) awaiting incorporation. • The application of UK safety classification for modifications. • Comments against the draft replacement PCSR UKP-GW-GL-793 Revision A. • Agreed responses Technical Queries (TQs), Regulatory Observations (ROs) and Regulatory Issues (RIs) generated during GDA Steps 2, 3, and 4. Based on their review, Westinghouse should either confirm that their PCSR UKP-GW-GL-793 Revision 0 is the extant GDA safety case and is suitable		

Technical Area		**CROSS CUTTING**	
Related Technical Areas		**None**	
GDA Issue Reference	**GI-AP1000-CC-02**	**GDA Issue Action Reference**	**GI-AP1000-CC-02.A1**
	and sufficient to substantiate the design defined in UKP-GW-GL-060 Revision 3 or submit a revised PCSR to the Regulators as necessary. Westinghouse is required to provide their safety case, Design Reference Document UKP-GW-GL-060 and the Master Submission List UKP-GW-GLX-001 and place subsequent updates on their website (removing commercial information, and security sensitive information) With agreement from the joint Regulators this action may be completed by alternative means.		

WESTINGHOUSE AP1000® GENERIC DESIGN ASSESSMENT

GDA ISSUE

PCSR TO SUPPORT GDA

GI-AP1000-CC-02 REVISION 3

<table>
<tr><td>Technical Area</td><td colspan="3">CROSS CUTTING</td></tr>
<tr><td>Related Technical Areas</td><td colspan="3">None</td></tr>
<tr><td>GDA Issue Reference</td><td>GI-AP1000-CC-02</td><td>GDA Issue Action Reference</td><td>GI-AP1000-CC-02.A2</td></tr>
<tr><td>GDA Issue Action</td><td colspan="3">Westinghouse is required to make and implement arrangements to control, maintain and develop the GDA safety submission documentation. This must include the SSER, MSL and design reference documents. As part of this action, Westinghouse shall deliver final consolidated versions of these documents as the key references to any DAC/SoDA ONR or the Environment Agency (the joint Regulators) may issue at the end of GDA.

This should involve the incorporation of all relevant amendments into the impacted documentation associated with design changes, including the Design Reference UKP-GW-GL-060 MSL and the PCSR. This should include any other additionally agreed design changes associated with other GDA issue Resolution Plans.

Westinghouse arrangements shall ensure no modification to the design or safety case, which may affect safety, is made except in accordance with agreed arrangements and will provide for the classification of modifications according to their safety significance.

Evidence the joint Regulators expect to see to address this action:
1. Application of Westinghouse due processes, including Quality Assurance (QA) and technical reviews for the control and development of the GDA submission documentation contained within the SSER, MSL and design reference document to address
1.1. GDA Issue resolution,
1.2. Agreed design changes
1.3. Any other updates agreed with the Regulators.
2. Application of Westinghouse due processes, including technical reviews, Independent Review and QA consolidation checks on final GDA submission documentation contained within the SSER, MSL and design reference document to be referenced from any DAC/SoDA ONR or the Environment Agency may issue. The joint Regulators will require:
2.1. Evidence that review comments have been managed and incorporated in the final consolidated documentation as necessary.
3. Timely delivery of final consolidated GDA submission documentation including SSER, MSL and design reference document to be referenced from any DAC/SoDA ONR may issue. Westinghouse will need to provide a public version of these documents made available via their website. To facilitate our assessments /inspections in this area, in addition to the submission of the documentation the joint Regulators will</td></tr>
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<table>
<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">None</td></tr>
<tr><td>GDA Issue Reference</td><td>GI-AP1000-CC-02</td><td>GDA Issue Action Reference</td><td>GI-AP1000-CC-02.A2</td></tr>
<tr><td></td><td colspan="3">require:
3.1. the programme of deliverables of amended impacted design change documentation which will need to allow sufficient time for us to complete our assessments before ONR or Environmental Agency may issue any DAC/SoDA.
With agreement from the joint Regulators this action may be completed by alternative means.</td></tr>
</table>

WESTINGHOUSE AP1000® GENERIC DESIGN ASSESSMENT

GDA ISSUE

PCSR TO SUPPORT GDA

GI-AP1000-CC-02 REVISION 3

<table>
<tr><td>Technical Area</td><td colspan="3">CROSS CUTTING</td></tr>
<tr><td>Related Technical Areas</td><td colspan="3">None</td></tr>
<tr><td>GDA Issue Reference</td><td>GI-AP1000-CC-02</td><td>GDA Issue Action Reference</td><td>GI-AP1000-CC-02.A3</td></tr>
<tr><td>GDA Issue Action</td><td colspan="3">Westinghouse to implement the outstanding GDA agreed design changes, by incorporating the change details into all impacted DR, the MSL documentation including the PCSR, ER.

The scope of this work should include those design changes already agreed for inclusion in GDA Step 4 but not incorporated and any additional design changes arising as part of other GDA issues resolution plans or arising during the GDA close out stage.

Evidence ONR or the Environment Agency (the joint Regulators) expect to see to address this action includes:
1. A revised Design Reference Document that shows the DCPs agreed by the regulators for inclusion in GDA which were not fully incorporated at the DRP of 16 September 2010.
2. A delivery schedule which;
2.1. Identifies when those DCPs identified in item 1 above and any subsequent DCPs agreed by the regulators for inclusion in GDA will be incorporated into the impacted support documentation in the MSL and DR
2.2. Identifies what design change details will be carried over into the site specific Phase, supported by a justification for this later delivery
3. Delivery of 2a part of the schedule and define the quality assurance arrangements to be applied for 2b.

To facilitate our assessments in this area the programme of deliverables of impacted GDA submission documentation should be phased to allow for early assessment of the process performance.

It is noted that some changes may not be incorporated into the GDA submission documentation until the site specific phase. This work needs to be clearly identified and agreed with the joint Regulators prior to the end of GDA.

Westinghouse to review the Design Reference Point and update the Design Reference Document as necessary to reflect incorporation of the design changes, submit this to the regulators and place any update on their website (removing commercial information, and security sensitive information) prior to the final GDA SSER submission.

With agreement from the joint Regulators this action may be completed by alternative means.</td></tr>
</table>

WESTINGHOUSE AP1000® GENERIC DESIGN ASSESSMENT

GDA ISSUE

CONSIDER AND ACTION PLANS TO ADDRESS THE LESSONS LEARNT FROM THE FUKUSHIMA EVENT

GI-AP1000-CC-03 REVISION 2

<table>
<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-AP1000-CC-03</td><td>GDA Issue Action Reference</td><td>GI-AP1000-CC-03.A1</td></tr>
<tr><td>GDA Issue</td><td colspan="3">Westinghouse 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.</td></tr>
<tr><td>GDA Issue Action</td><td colspan="3">Westinghouse to address the lessons learnt from their internal review following the Fukushima event relevant to GDA for the AP1000.

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-AP1000-TR.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 Westinghouse Level III Procedure Design Reference Point Change for GDA. UKP-GW-GAP-026 Revision 0.

With agreement from the Regulators this action may be completed by alternative means.</td></tr>
</table>

WESTINGHOUSE AP1000® GENERIC DESIGN ASSESSMENT

GDA ISSUE

CONSIDER AND ACTION PLANS TO ADDRESS THE LESSONS LEARNT FROM THE FUKUSHIMA EVENT

GI-AP1000-CC-03 REVISION 2

<table>
<tr><td>Technical Area</td><td colspan="3">CROSS CUTTING</td></tr>
<tr><td>Related Technical Areas</td><td colspan="3">All</td></tr>
<tr><td>GDA Issue Reference</td><td>GI-AP1000-CC-03</td><td>GDA Issue Action Reference</td><td>GI-AP1000-CC-03.A2</td></tr>
<tr><td>GDA Issue</td><td colspan="3">Westinghouse 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.</td></tr>
<tr><td>GDA Issue Action</td><td colspan="3">Westinghouse to address the lessons learnt that are relevant to GDA for AP1000 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-AP1000-TR.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 Westinghouse Level III Procedure Design Reference Point Change for GDA. UKP-GW-GAP-026 Revision 0.

With agreement from the Regulators this action may be completed by alternative means.</td></tr>
</table>

Annex 2 – Compilation of assessment findings

1178 We expect Westinghouse or a future operator, as appropriate, to address the following assessment findings during the detailed design, procurement, construction or commissioning phase of any new build project:

Reference	Assessment finding
AP1000-AF01	The future operator shall provide at the detailed design stage, an updated decommissioning strategy and decommissioning plan.
AP1000-AF02	Future operators shall, at the detailed design phase, provide a BAT assessment to demonstrate whether boron recycling represents BAT for their location.
AP1000-AF03	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.
AP1000-AF04	Future operators shall, before the construction phase, provide a BAT assessment to demonstrate that the design and capacity of secondary containment proposed for the monitor tanks is adequate for their location
AP1000-AF05	Future operators shall, at the detailed design phase, provide an assessment to demonstrate that techniques to minimise the discharge of all aqueous radioactive wastes are BAT for their location. In particular, the omission of an evaporator will need to be justified.
AP1000-AF06	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.
AP1000-AF07	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 Westinghouse's plan for disposability of ILW.
AP1000-AF08	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).

Reference	Assessment finding
AP1000-AF09	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).
AP1000-AF10	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, if the Westinghouse reference dry spent fuel storage option is not chosen. The future operator shall provide an assessment to show that the techniques proposed are BAT.
AP1000-AF11	The future operator shall provide confidence, before the commissioning phase 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 Westinghouse's plan for disposability of spent fuel.
AP1000-AF12	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 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.

Annex 3 – Final assessment reports

Document reference	Title Generic design assessment AP1000 nuclear power plant design by Westinghouse Electric Company LLC Final Assessment Report -
EAGDAR AP1000-01	Management Systems
EAGDAR AP1000-02	Integrated Waste Strategy
EAGDAR AP1000-03	Best Available Techniques to prevent or minimise the creation of radioactive wastes
EAGDAR AP1000-04	Gaseous radioactive waste disposal and limits
EAGDAR AP1000-05	Aqueous radioactive waste disposal and limits
EAGDAR AP1000-06	Solid radioactive waste (LLW and ILW)
EAGDAR AP1000-07	Spent Fuel
EAGDAR AP1000-08	Disposability of ILW and Spent Fuel
EAGDAR AP1000-09	Monitoring of radioactive disposals
EAGDAR AP1000-10	Generic site
EAGDAR AP1000-11	Radiological impact on members of public
EAGDAR AP1000-12	Radiological impact on non-human species
EAGDAR AP1000-13	Other Environmental Regulations
IMAS/TR/2010/06 EAGDAR AP1000-14	Independent Dose Assessment

Annex 4 – AP1000: range of discharges from operating PWRs

A4.1 Introduction

1179 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*.'

1180 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 liquid and solid waste as well.

1181 By gaseous waste we mean contaminated air, particulate, gases and vapours released from the reactor or areas where contaminated materials or waste are handled. Liquid 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.

1182 This annex covers only low level radioactive waste, it does not cover higher activity waste or irradiated nuclear fuel.

1183 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.

1184 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.

1185 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.

1186 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.

1187 This annex is in two parts: firstly a section covering the discharges from operating reactors that are immediate predecessors to the AP1000 to compare the discharges per unit of electricity generated with those claimed for the AP1000; 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.

1188 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

1189 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 eight 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 liquid 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

1190 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

1191 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.

1192 This annex covers the AP1000 only.

1193 It provides discharge information from six operating nuclear power stations - including Sizewell B - that are predecessors to the AP1000 design.

1194 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

1195 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.

<u>A4.3.2.1 Gaseous discharges</u>

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 – **AP1000**	'90-'06	2 – 1000	20 - 30	0.6 - 900	0.003 - 290	0.06 - 20
	'00-'04	6 – 30	0.4 – 1000	0.003 – 300	0.002 – 60	

A3.3.2.2 Aqueous discharges

Table 2: Releases of liquid waste from operating stations

	Aqueous release	
	Tritium (GBq/GWeh)	**Other Radionuclides (kBq/GWeh)**
Predecessor actual – **AP1000**	1 – 8 2 – 8	20 – 10000 40 - 8000

Notes:

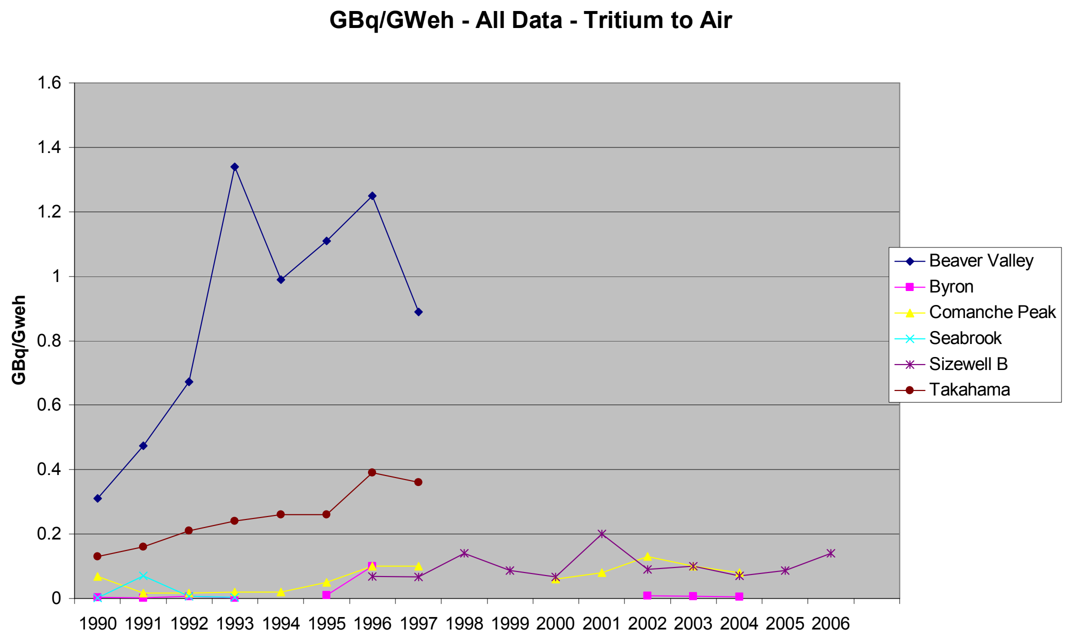
1) The ranges presented in tables 1 and 2 represent the range of activity in discharges over the seventeen-year reporting period.
2) The science report breaks down discharges of liquid waste into two categories – tritium and other.
3) Figures have been rounded to one significant figure.

1196 We looked at the ranges for two release categories from more recent discharges – noble gas and iodine discharges to air from the AP1000 predecessor stations during the five year period 2000-2004. We chose this period as the data set is well populated and it represents a long enough period after commissioning that operators should be able to control discharges. Surprisingly, the ranges were almost the same as for the seventeen year period.

A4.3.3 AP1000 PREDECESSOR STATIONS

<u>Gaseous tritium</u>

1197 Below is a graph of all of the gaseous tritium discharges for AP1000 predecessor stations:-



1198 The high gaseous releases were mainly from Beaver Valley power station. The science report acknowledged that 'significantly higher airborne discharges were observed in 1993 and 1996………….. a possible cause of this increase in 1993 was the accumulation of gas due to inadequate venting……….etc'

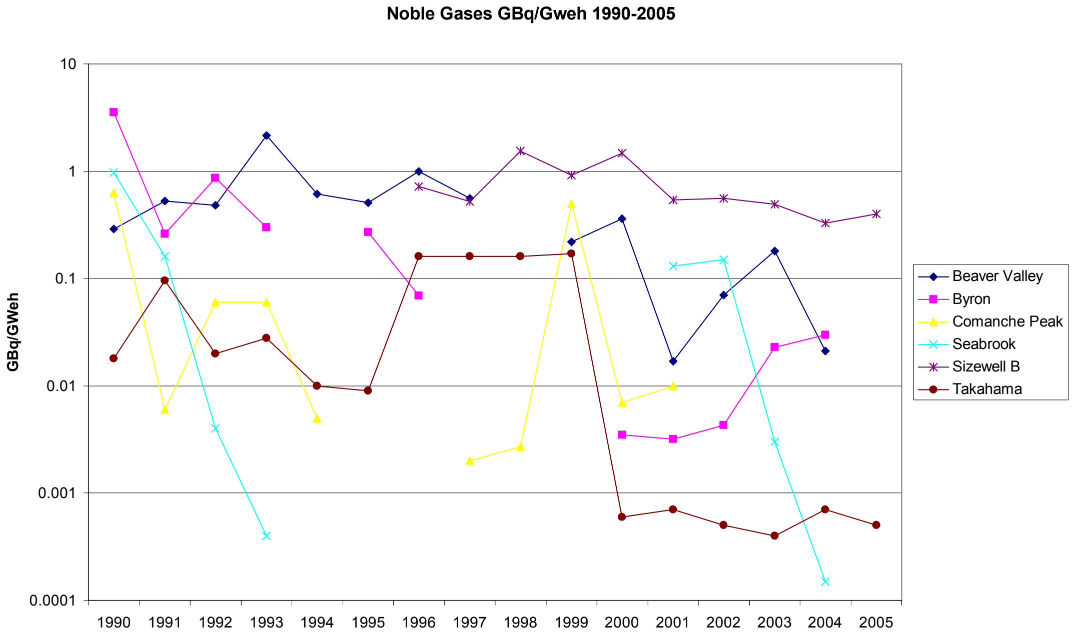
1199 It may be prudent to disregard gaseous discharges of tritium from the Beaver Valley power station as they seem unusually high compared to other predecessor stations and we know there has been a period of operation giving rise to particularly high discharges, which might not be relevant to new build stations.

1200 **Takahama** the discharges from Takahama seem significantly higher than the remaining predecessor stations. The science report gives no insight as to why that should be.

1201 The graph indicates that 75 per cent of discharges were in the range 0.05 - 0.2 GBq/GWeh. This is a comparatively narrow range.

Noble gases

1202 Below is a graph of all the gaseous noble gas discharges for AP1000 predecessor stations: -



1203 The science report indicates the following unusually high discharges of noble gases:

1) Beaver Valley power station as indicated in the previous section;

2) peak in airborne discharges from the Byron power station for 1990;

3) from the Comanche Peak power station in the period 1990 to 1992;

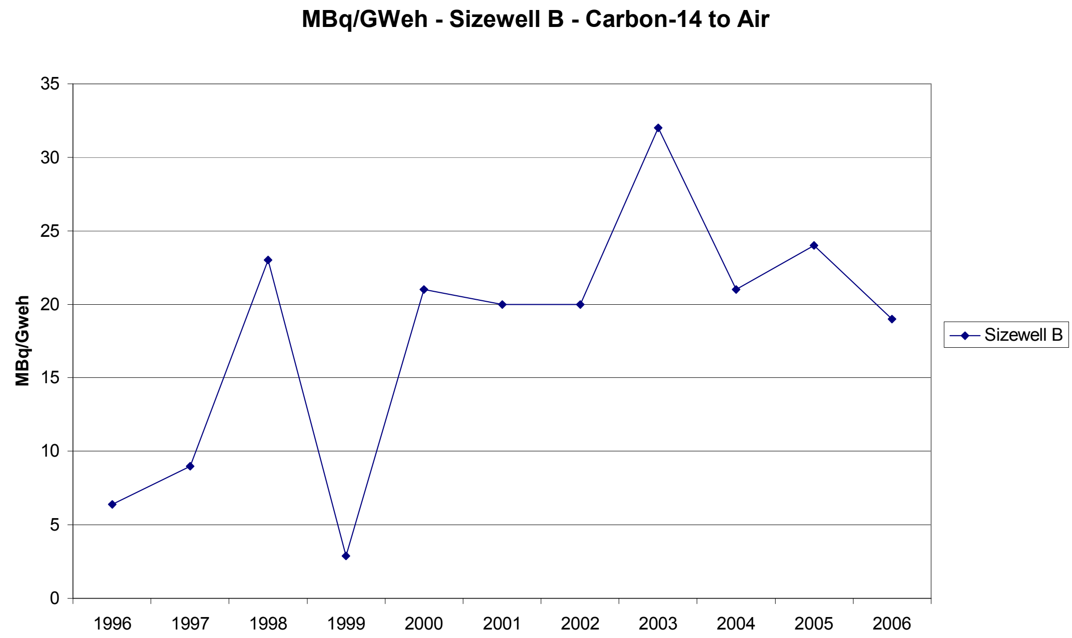
4) from the Sizewell B power station for the years 1998 and 2000.

1204 Disregarding these unusually high discharges, predecessor stations have operated within a very wide range of discharges of noble gases to air from very low levels up to 1 GBq/GWeh.

1205 Recent discharges will be a better indicator for future discharges: 75 per cent of the discharges reported in the last five years are in the range 0.5 – 200 MBq/GWeh - this may be a reasonable range to expect new build stations to better.

Carbon-14

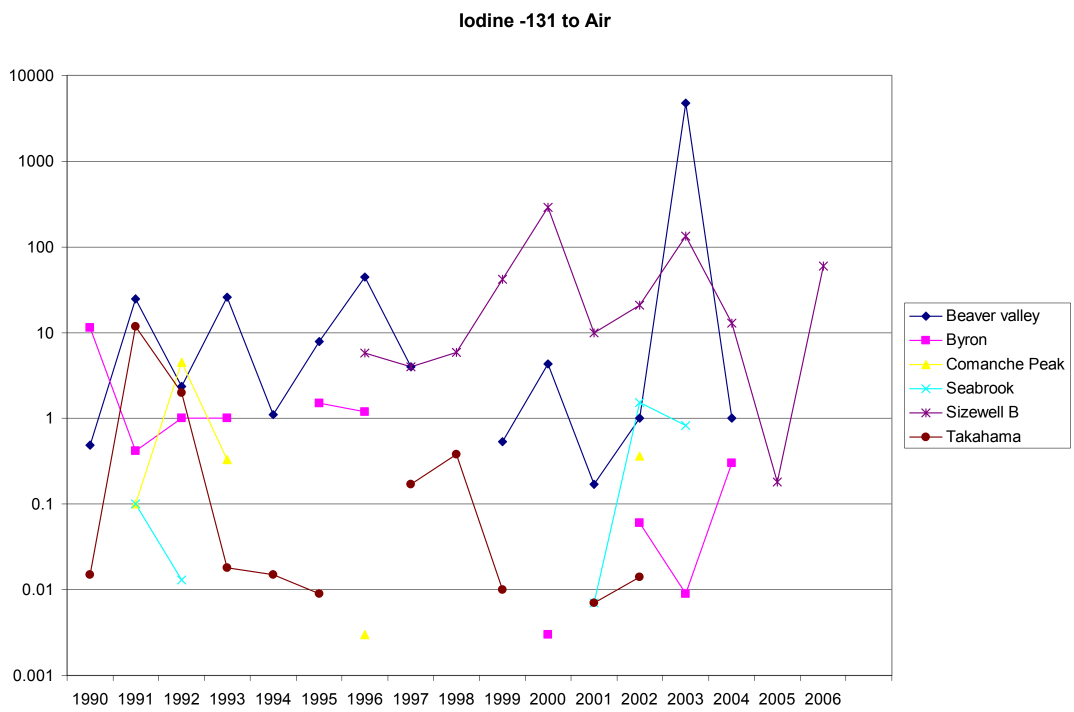
1206 The science report found only data for gaseous discharge of carbon-14 from Sizewell B.



1207 This indicates that the Sizewell B power station operated with 75 per cent of carbon-14 discharges in the range: 8-25 MBq/GWeh.

Iodine -131

1208 Below is a graph of all the iodine-131 gaseous discharges for AP1000 predecessor stations:

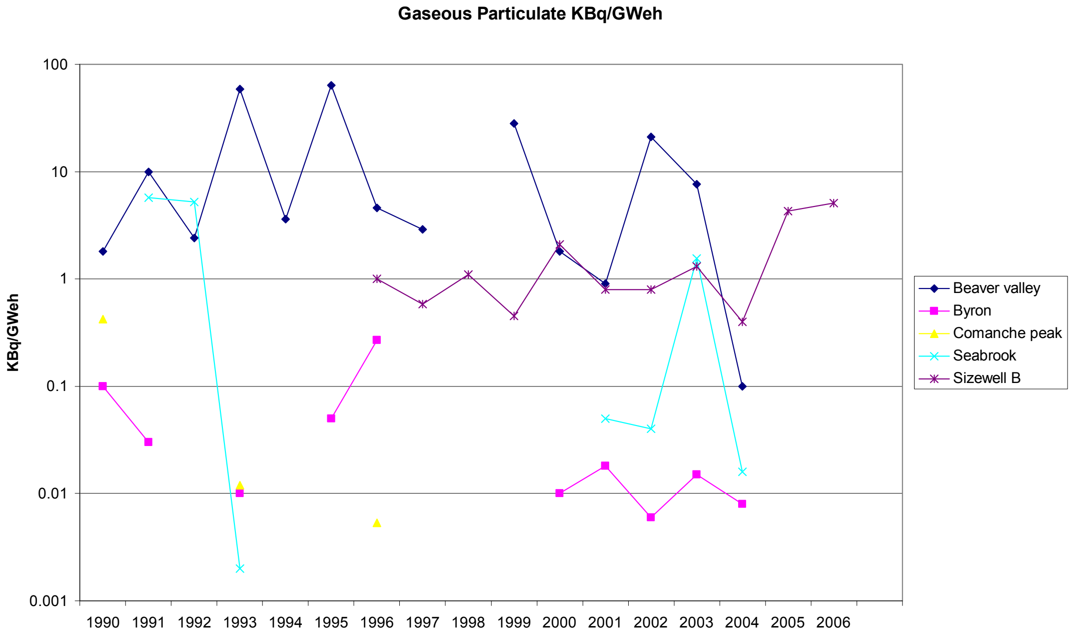


1209 The science report excluded the very high discharge from Beaver Valley. The remaining data is extremely variable. Sets of discharge data are largely incomplete for all stations.

1210 75 per cent of the reported discharges are within the range 0.01 – 30 kBq/GWeh.

Gaseous particulate

1211 Below is a graph of all the particulate gaseous discharges for AP1000 predecessor stations:



1212 The science report indicates no unusually high discharges of gaseous particulate.

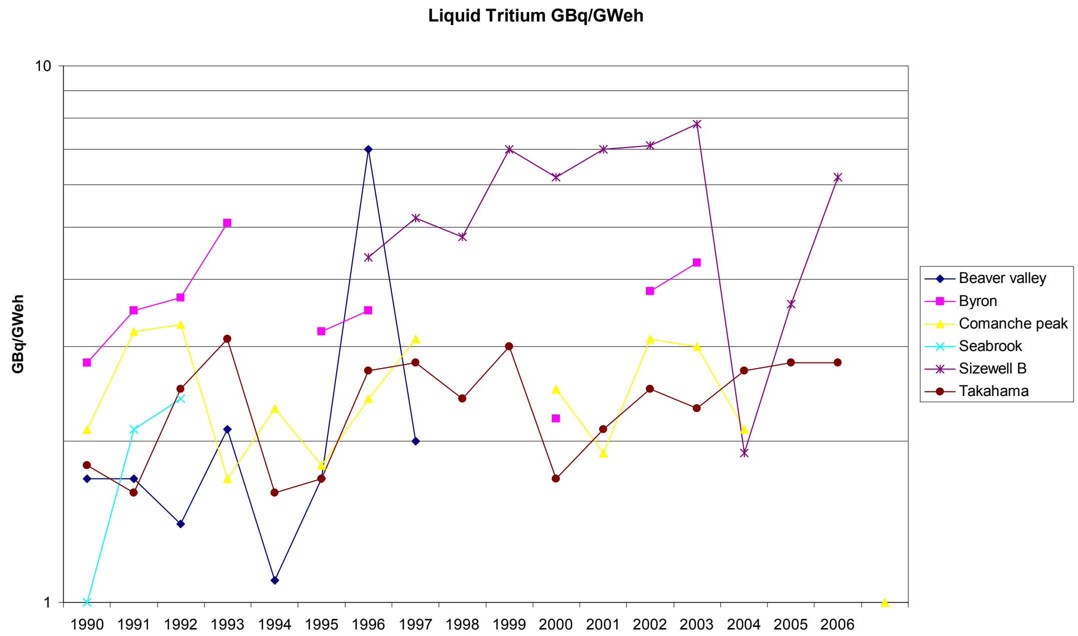
1213 There is no data for Takahama and limited data for Comanche Peak.

1214 The data for Sizewell B power station indicates an average of 1 kBq/GWeh and much higher discharges from Beaver Valley power station.

1215 75 per cent of the reported discharges are within the range 0.01 – 5 kBq/GWeh.

Aqueous tritium

1216 Below is a graph of all the liquid tritium gas discharges for AP1000 predecessor stations:

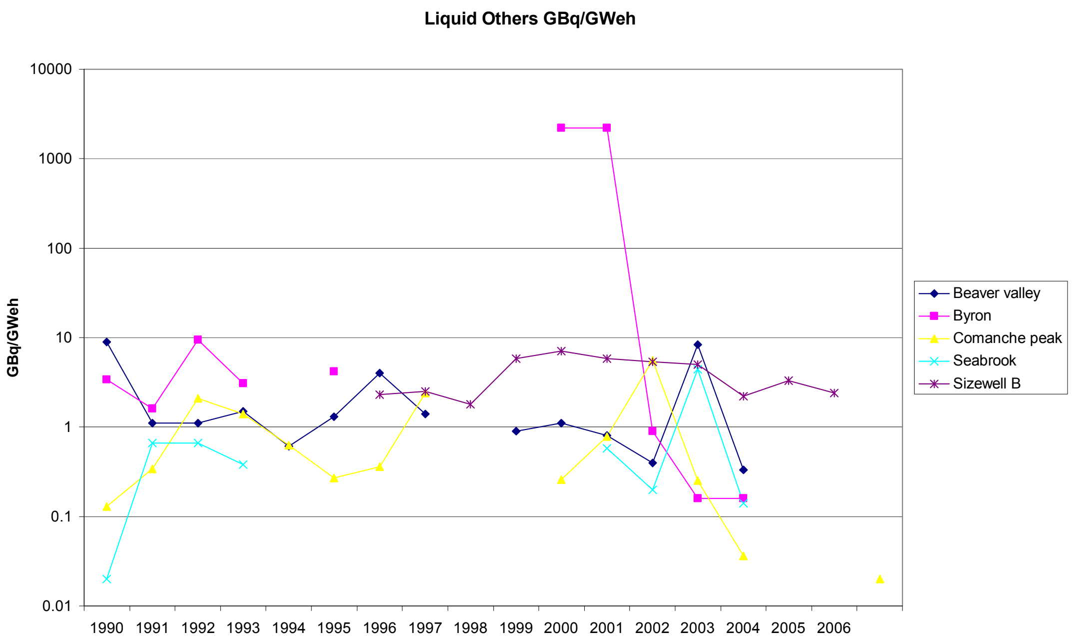


1217 This indicates that 75 per cent of the discharges are within the range 2 - 4 GBq/GWeh.

1. The particularly high discharge from Beaver Valley in 1996 is attributed to a particular event as mentioned in the science report.
2. Sizewell B discharges are relatively very high for most years.

Aqueous Other radionuclides

1218 Below is a graph of all the liquid other radionuclides for AP1000 predecessor stations: -



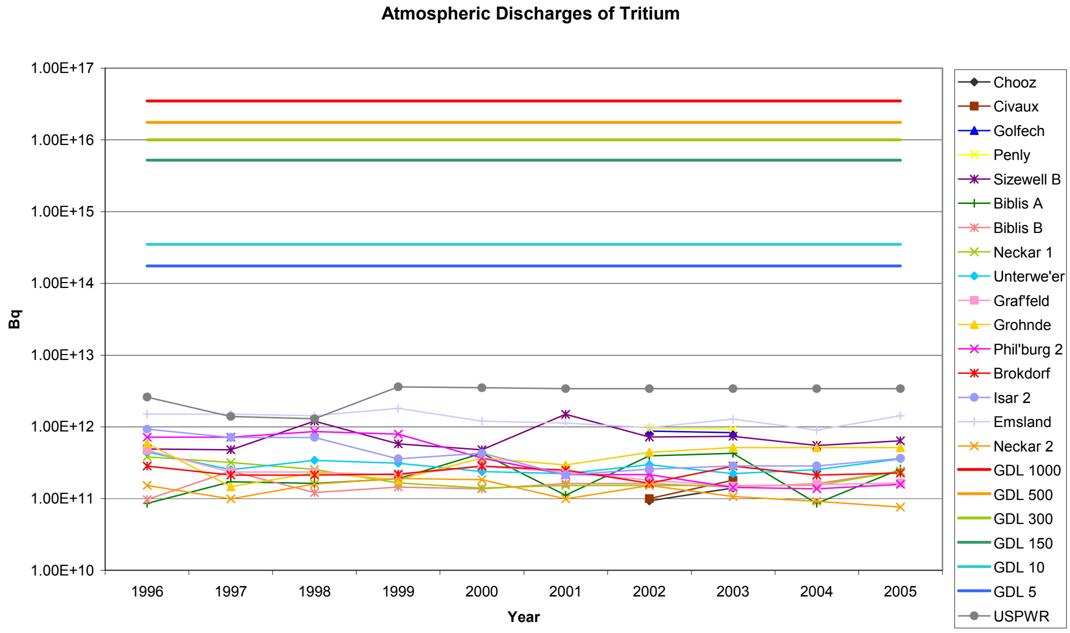
1219 This indicates that 75 per cent of the discharges are within the range 0.5 - 10 GBq/GWeh.

A4.4 Section Two - Average discharges from the wider PWR sector

A4.4.1 Atmospheric discharges

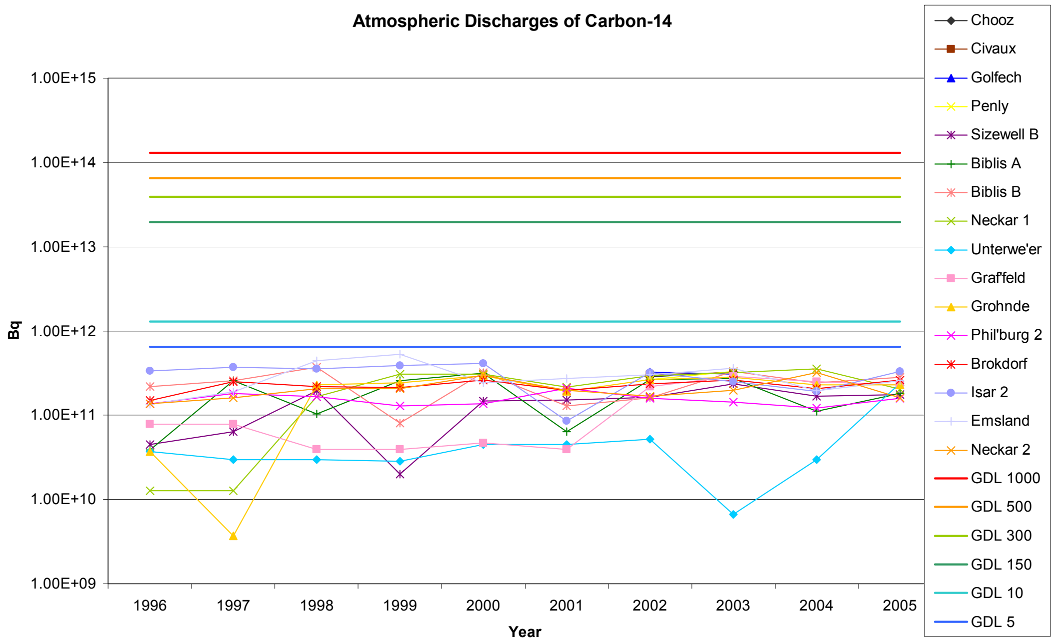
Tritium - Atmospheric discharge

1220 From our examination of historic discharges from European PWRs (References 1 and 3) and US PWRs (Reference 2) operating over the last ten 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.



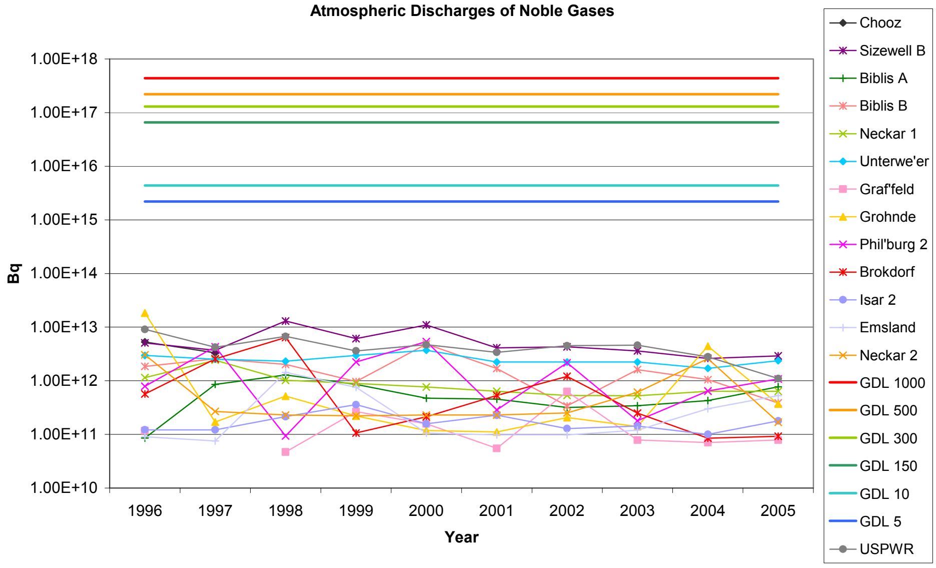
Carbon-14 - Atmospheric discharge

1221 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.



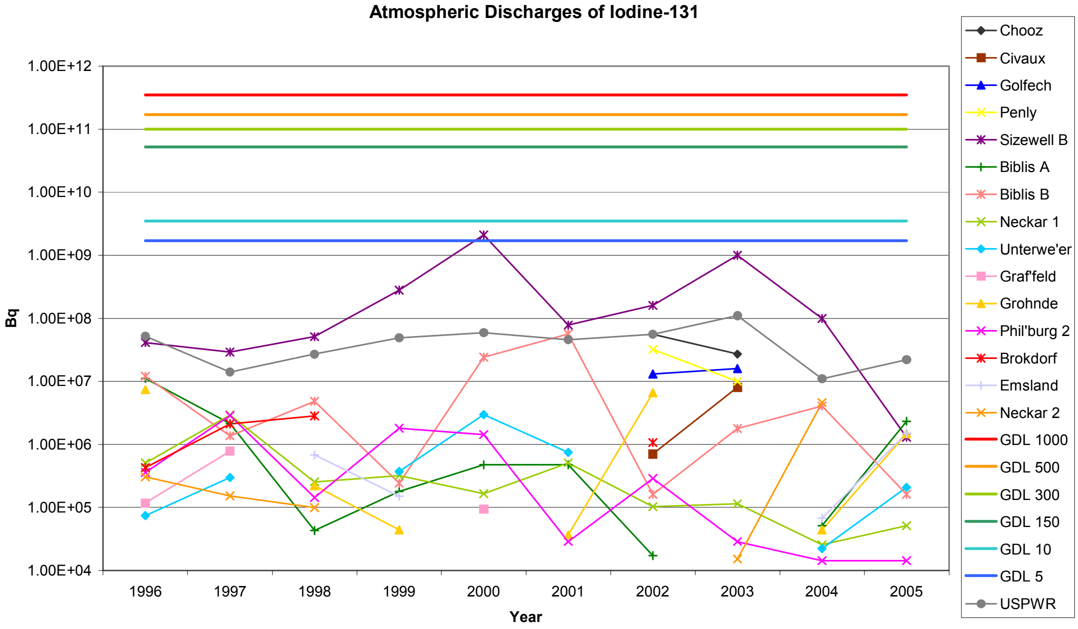
Noble gases - Atmospheric discharge

1222 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

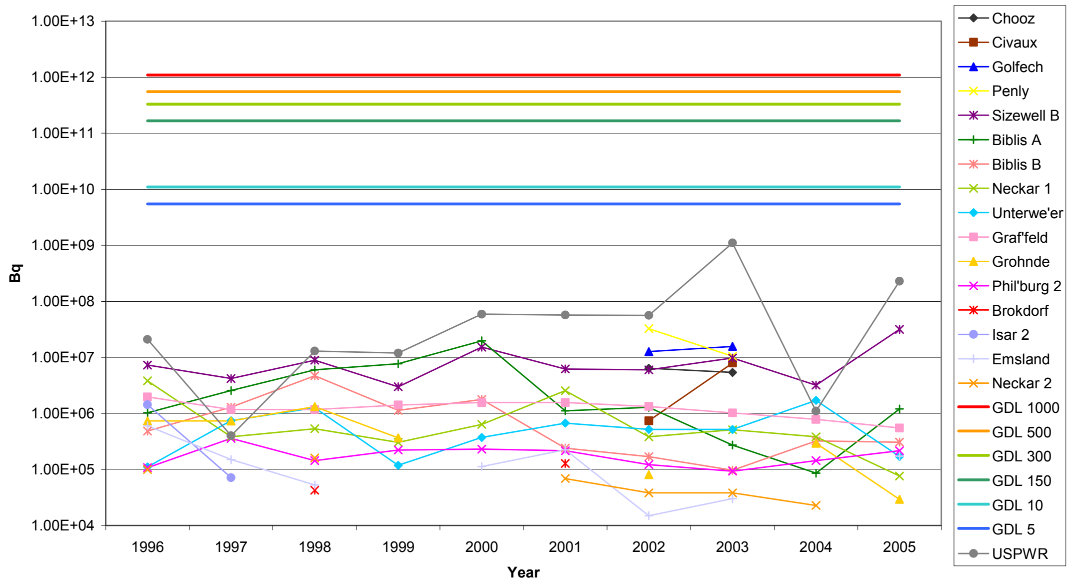
1223 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to atmosphere of iodine-131 there is a normal operating range of from less than 1 to 2000 MBq per annum for a 1000 MWe power station. At the maximum 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

1224 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 one 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

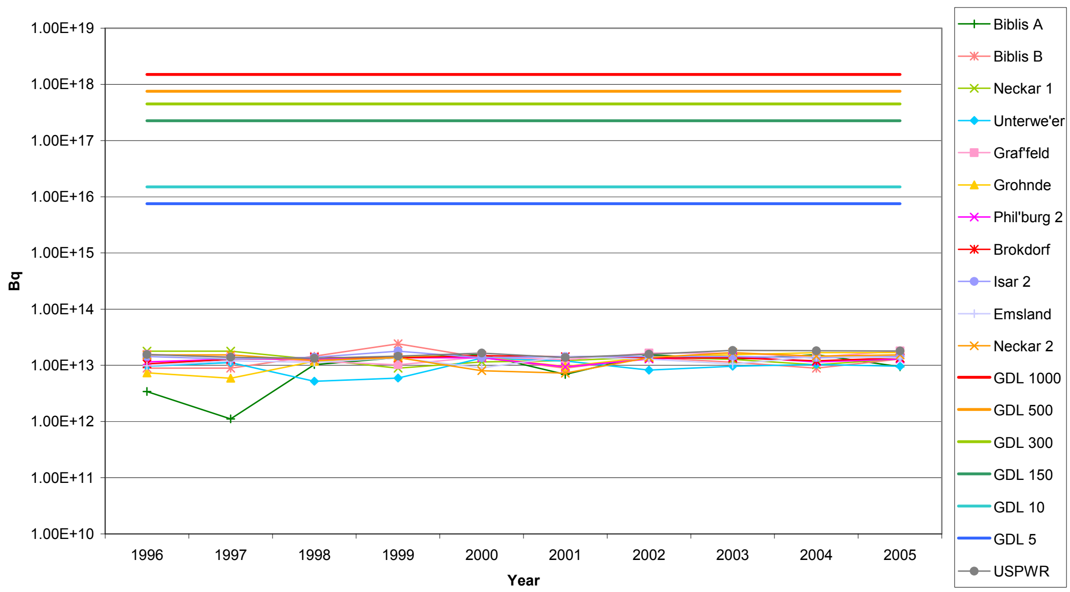


A4.4.2 Aqueous discharges

Tritium - aqueous discharge

1225 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

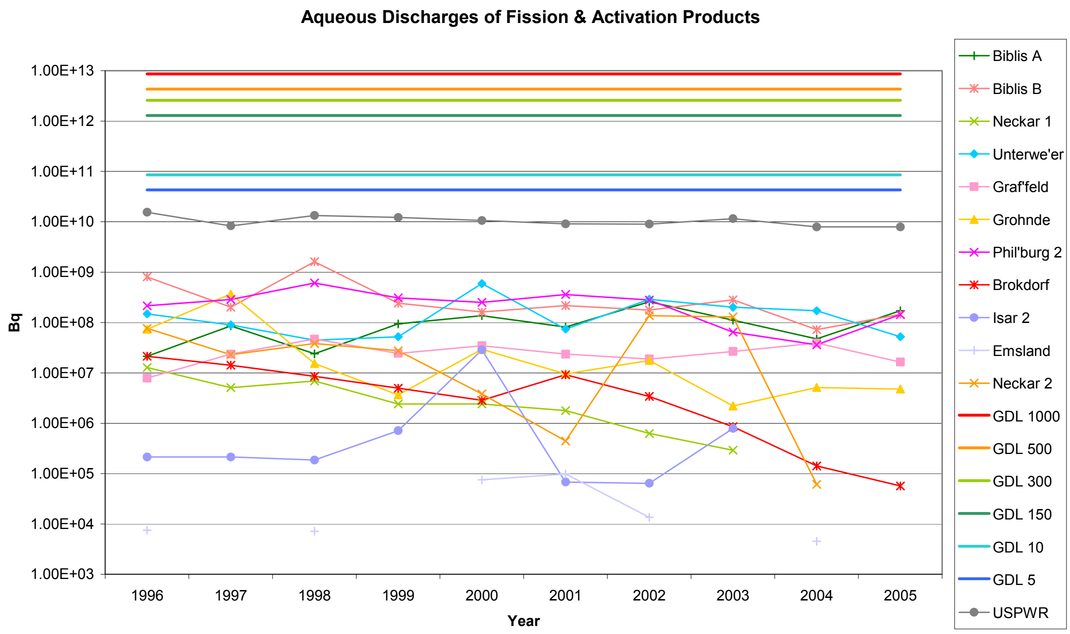
1226 From our limited information about PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to water of carbon-14 there is a normal operating range of 3 to 45 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 20 μSv.

Iodine - Aqueous discharge

1227 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

1228 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 one 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 one 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[9], 1999)	3600 GBq
Minimum discharge within one year from a single site (Neckar 2, 2005)	76 GBq

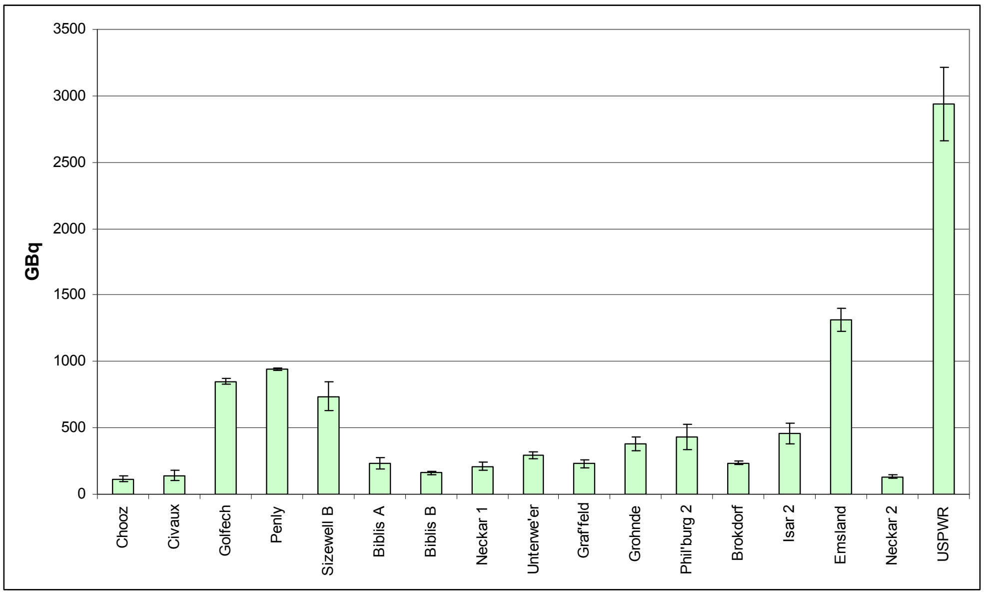


Figure 1: Mean atmospheric discharge of tritium between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

1229 The data for atmospheric discharges[10] 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. USPWRs report substantially greater discharges than the German and French reactors, as well as Sizewell B.

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9 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.

10 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

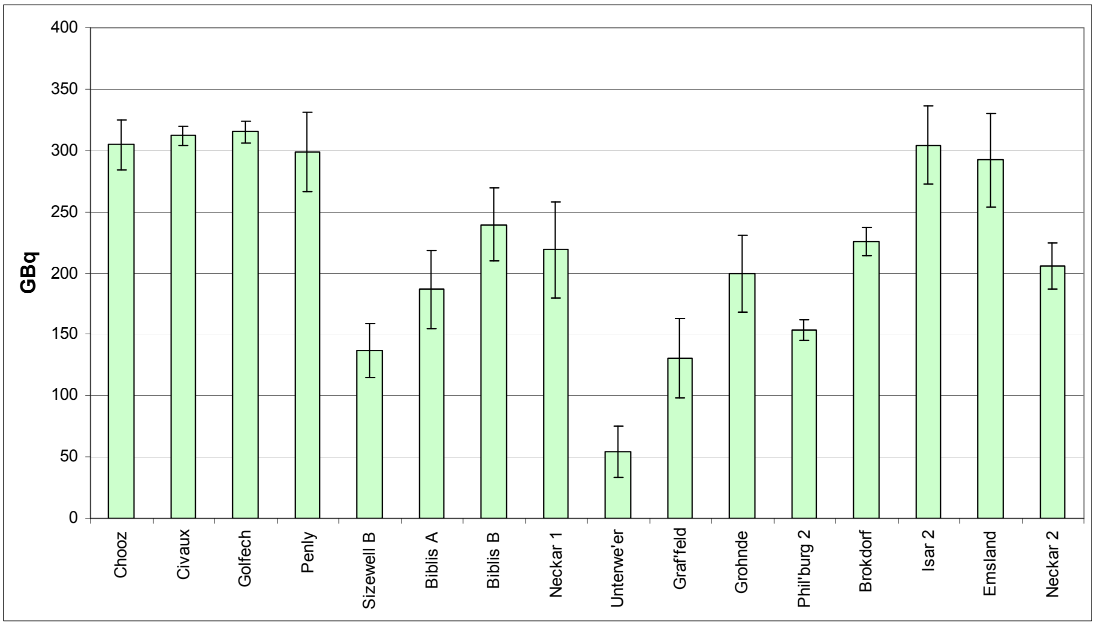

Figure 2: Mean atmospheric discharge of carbon-14 between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

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

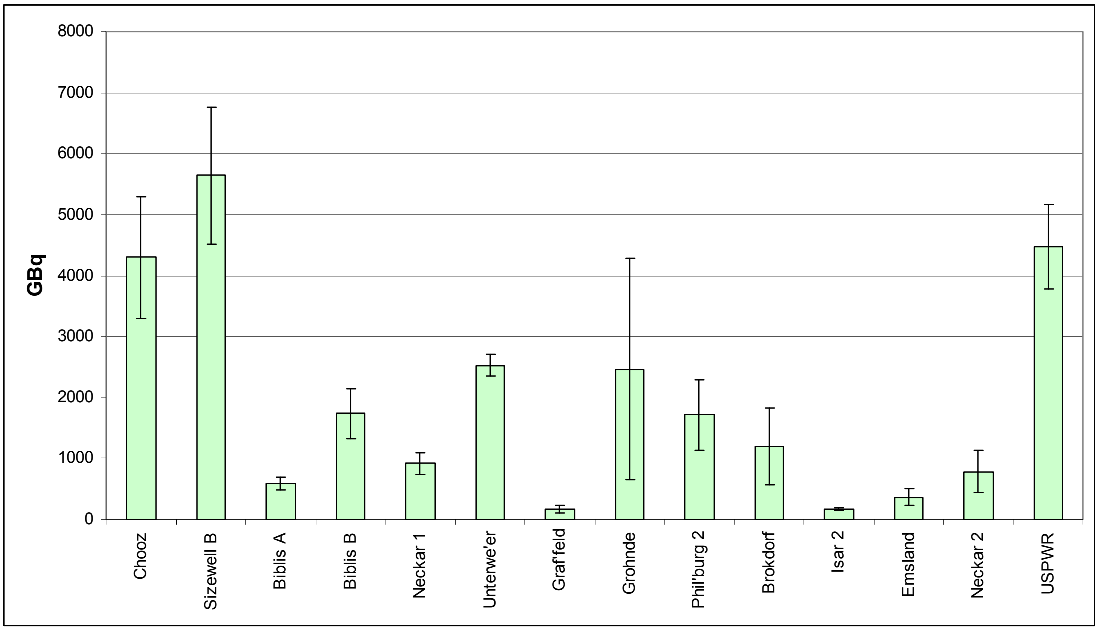

Figure 3: Mean atmospheric discharge of noble gases between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

1231 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

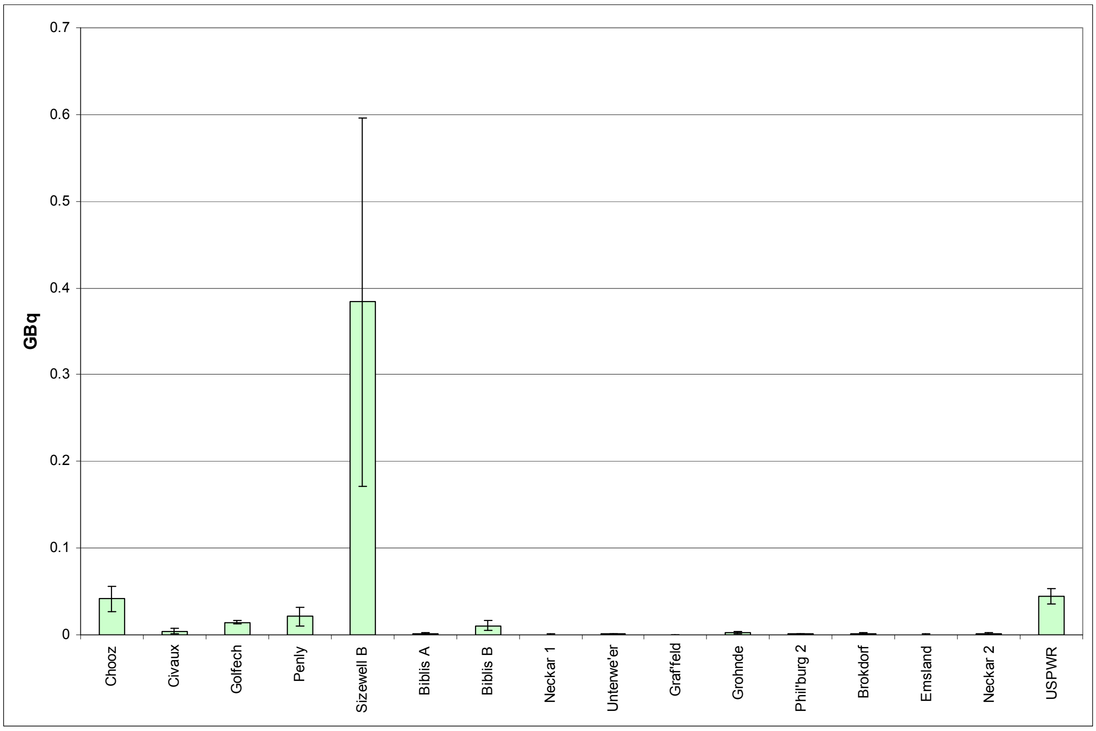

Figure 4: Mean atmospheric discharge of iodine-131 between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

1232 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, though 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

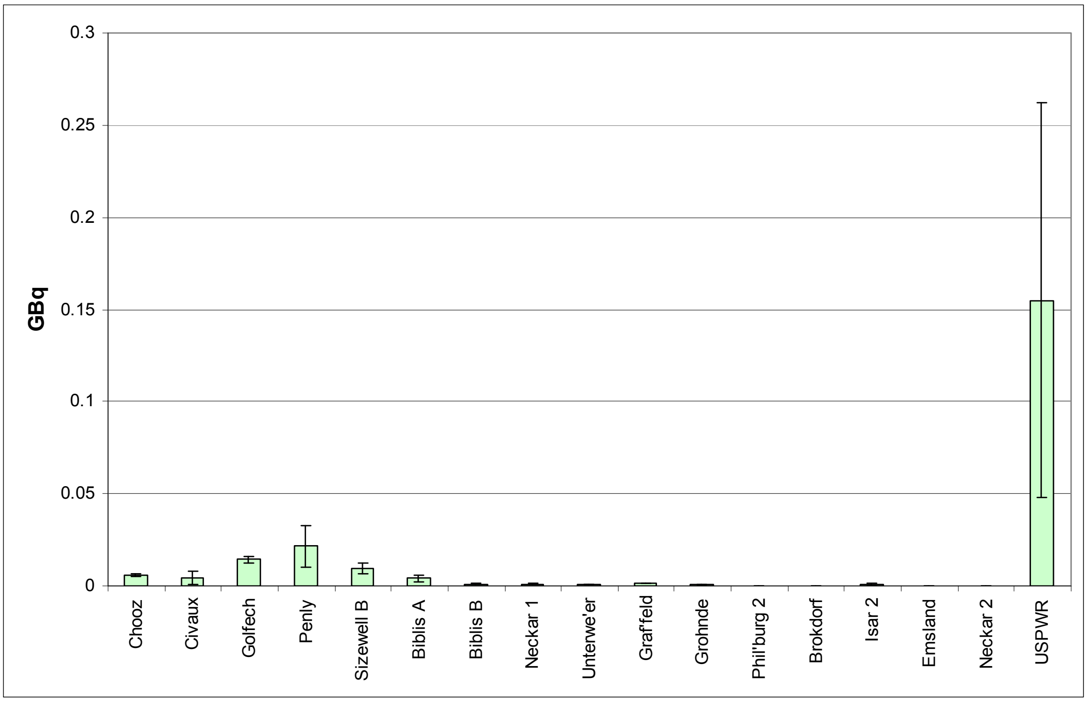

Figure 5: Mean atmospheric discharge of fission and activation products between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

1233 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

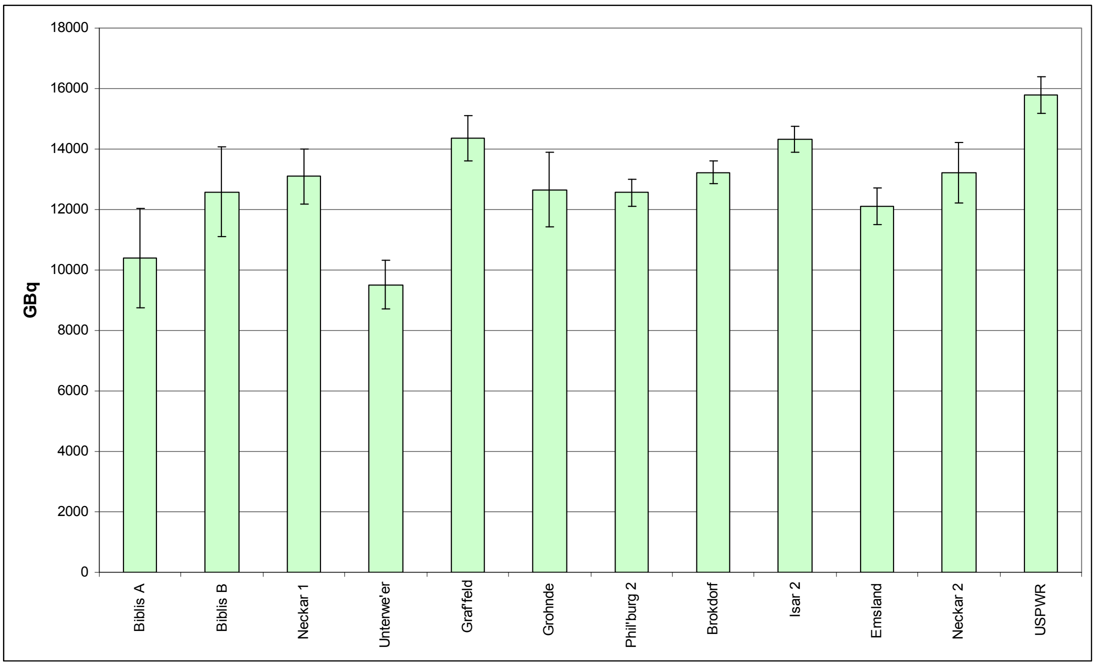

Figure 6: Mean aqueous discharge of tritium between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

1234 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

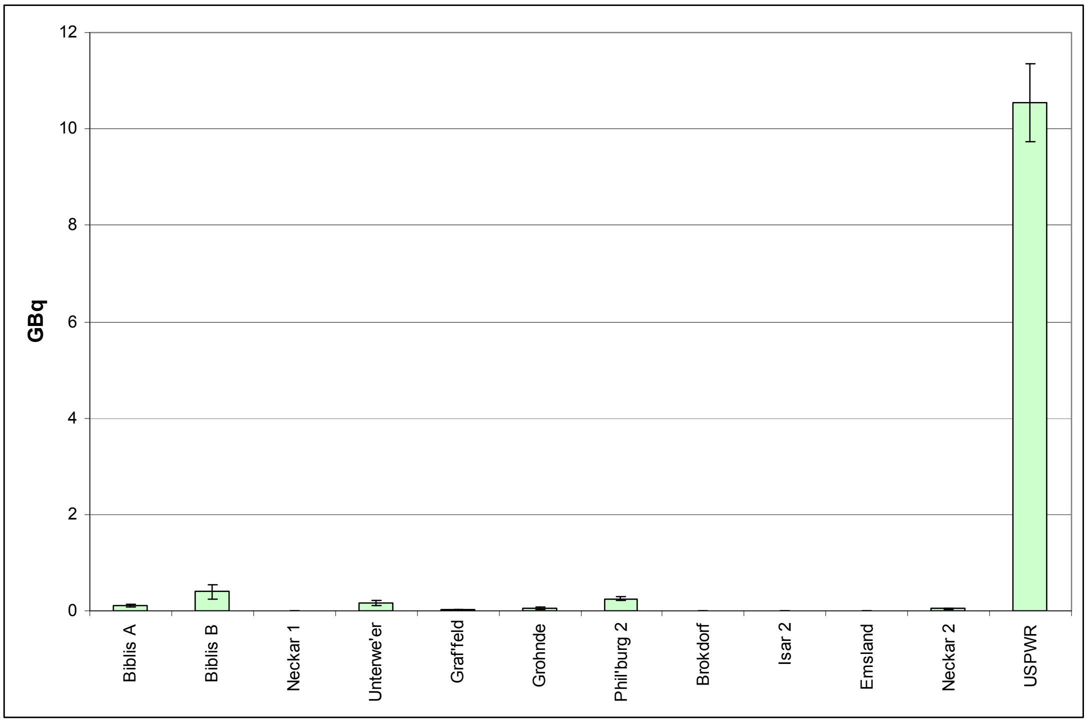

Figure 7: Mean aqueous discharge of fission and activation products between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

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.*

1. Radiological Effluents Released by US Commercial Nuclear Power Plants from 1995-2005. Health Physics December 2008, Volume 95, Number 6

2. Environment Agency Science Reports SC070015/SR1 and 2.

Annex 5 – Consultation questions

1236 Below is a list of questions that we had asked for responses to as part of our consultation on the AP1000 design:

1237 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

1238 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

1239 A poster advertising the consultation was sent to 1798 local authority run libraries in England and Wales.

1240 A poster advertising the consultation was sent to 743 public sector management libraries in England and Wales.

Print media

1241 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.

1242 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.

1243 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 can 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

1244 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.

1245 We also wrote to MPs, MEPs and Welsh AMs and provided information to those who requested it.

1246 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

1247 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	GDA47
Blackwater Against New Nuclear Group (BANNG)	GDA113
Bradwell for Renewable Energy	GDA122
Braystones Residents	GDA77
Burneside Parish Council	GDA34
Centre for Environmental Policy, Imperial College, London	GDA85
Committee on Medical Aspects of Radiation in the Environment (COMARE)	GDA130
Communities Against Nuclear Expansion (CANE)	GDA49

Member of Public/Company/Organisation	**ID**
Countryside Council For Wales	GDA144
Cumbria County Council	GDA167
Dept of Agriculture, Belfast	GDA55
Fylde Borough Council	GDA87
Greater Manchester Socialist Environment Resources Association (SERA)	GDA125
Greenpeace	GDA152
Health & Safety Executive, Nuclear Directorate	GDA76
Health Protection Agency (HPA)	GDA89
Horizon Nuclear Power	GDA128
Ingleby Barwick Town Council	GDA39
Institute of Mechanical Engineers	GDA146
Joint Nature Conservation Committee (JNCC)	GDA29
Kent Against a Radioactive Environment (KARE)	GDA148
L2 Business Consulting Limited	GDA124
Low Level Radiation and Health Conference	GDA156
Maldon Town Council	GDA59
Member of Public	GDA10
Member of Public	GDA14
Member of Public	GDA24
Member of Public	GDA26
Member of Public	GDA31
Member of Public	GDA33
Member of Public	GDA93
Member of Public	GDA79
Member of Public	GDA57
Member of Public	GDA45
Member of Public	GDA43
Member of Public	GDA53
Member of Public	GDA120
Member of Public	GDA136
Member of Public	GDA140
Member of Public	GDA160
Member of Public	GDA37
Member of Public	GDA169

Member of Public/Company/Organisation	ID
Nuclear Consultation Group	GDA150
Nuclear Industry Association	GDA118
Nuclear Legacy Advisory Forum (NuLeAF)	GDA81
Nuclear Technology Subject Group of the Institution of Chemical Engineers	GDA71
Nuclear Waste Advisory Associates (NWAA)	GDA134
Nuclear-Free Local Authorities (NFLA)	GDA83
Parents Concerned About Hinkley	GDA22
People Against Wylfa B (PAWB)	GDA99
RWE NPower	GDA138
Safety and Reliability Society	GDA108
Scottish Power	GDA164
Seafish	GDA91
Shepperdine Against Nuclear Energy (SANE)	GDA116
Shepway District Council	GDA101
Somerset County Council	GDA162
Springfields Site Stakeholder Group	GDA97
Stop Hinkley	GDA159
Studsvik UK Ltd	GDA132
Swedish NGO Office for Nuclear Waste Review, MKG	GDA61
Waldringfield Parish Council	GDA104
Welsh Assembly Government	GDA142
West Somerset Council and Sedgemoor District Council	GDA155
Westinghouse UK	GDA110

Annex 8 – Other consultation comments

Issues raised about multi-reactors sites & cumulative impacts with existing reactors

1248 Some respondents (GDA144) 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.

1249 Similarly, some respondents asked about whether cumulative impacts arising from existing nuclear installations adjacent to the new build sites had been assessed in GDA.

1250 Some respondents said that the actual impact can only be assessed when the new reactor is in operation.

Our Response

1251 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 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 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/)

1252 It is normal practice to carry out impact assessments using models and predictions of performance for new reactor designs, not least because no AP1000 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

1253 Some respondents (GDA82, GDA83) 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

1254 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 AP1000 and UK EPR 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

1255 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

1256 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

1257 Some respondents considered that creation of radioactive waste can be avoided by not building new nuclear power stations and therefore they should not be built.

1258 Some respondents (GDA81, GDA167) asked about whether a robust approach was being taken with regard to uncertainties and risks of national policies and strategies.

1259 Some respondents (GDA82, GDA83, GDA156 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.

1260 Some considered (GDA83, GDA150) that interim stores could actually become permanent disposal sites.

1261 Some (GDA116, GDA122, GDA154, GDA155) were concerned about impacts on their local communities of long term interim waste storage and some that local communities were not well informed about the proposals.

1262 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.

1263 Some (GDA83, GDA116) 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.

1264 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."

1265 Some respondents asked what would be the fallback if West Cumbria sites are not suitable for a GDF.

1266 Some respondents were concerned about the timescales for a GDF or asked about how this matter would be addressed in the planning system. 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.

1267 Some respondents (GDA59, GDA93) 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.

1268 Other respondents (GDA152) considered that a change of spent fuel management proposals to include reprocessing would have massive financial and environmental consequences.

Our Response

1269 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.

1270 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).

1271 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 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'.*

1272 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.

1273 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, as for GDA, 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, should be capable of being disposed of in the GDF once available.

1274 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

1275 Some respondents (GDA81) 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.

1276 Some respondents questioned DECC's waste and decommissioning proposals that propose that Government will take title to waste and spent fuel once decommissioning 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.

1277 Some (GDA120) were concerned about the potential creation of a national facility.

1278 Some respondents (GDA104) were concerned about the security of spent fuel stores.

Our Response

1279 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 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.

1280 The Government has set out its base case assumption is 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

1281 Some respondents (GDA156) asked about whether Regulators are confident that they can deal with long term issues – climate change for example.

1282 Some respondents noted that possible changes in the pipeline such as with regard to radiation dose limits are not addressed.

1283 A respondent (GDA157) 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.

1284 A respondent (GDA83) noted that the potential implications for higher dose rates from transport flasks along transport routes had not been examined

1285 A respondent (GDA157, GDA159) expressed concern about a decision of the NDA to incinerate reactor core graphite.

Our Response

1286 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 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.

1287 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 e.g. 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.

1288 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.

1289 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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