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DEPARTMENT OF ENERGY & CLIMATE CHANGE

UK Strategy for Radioactive Discharges

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1. Radioactive wastes, some of which may be discharged into the environment as liquids, gases, mists or dusts are generated by the use of radioactive materials in a wide range of day-to-day applications. Such discharges are regulated under the Radioactive Substances Act 1993 (RSA93) and are subject to strict limits where appropriate, in line with the regulators' own limit setting criteria.

2. This revised UK Strategy for Radioactive Discharges updates Government policy and describes how the UK will continue to implement the agreements reached at the 1998 OSPAR[1] Ministerial meeting, and subsequent OSPAR meetings on radioactive substances, particularly the Radioactive Substances Strategy (RSS). This builds on the initial UK Strategy, published in 2002, and expands its scope to include aerial, as well as liquid discharges, from decommissioning as well as operational activities, and from the non-nuclear as well as the nuclear industry sectors. A draft version of this document was the subject of a public consultation in 2008.

3. Whereas the 2002 Strategy for Radioactive Discharges was written in the context of a declining nuclear industry in the UK, current expectations are that nuclear generating capacity from existing power stations will be required for longer and the UK Government believes that new nuclear power stations should have a role to play in this country's energy mix alongside other low-carbon sources. The challenge of this revised Strategy will be to deliver the UK's commitments to OSPAR in a way that does not compromise UK Government's energy policy.

4. The objectives of this revised Strategy are:

   - to implement the UK's obligations, rigorously and transparently, in respect of the OSPAR Radioactive Substances Strategy (RSS) intermediate objective for 2020;
   - to provide a clear statement of Government policy and a strategic framework for discharge reductions, sector by sector, to inform decision making by industry and regulators

   The expected outcomes of the UK Strategy are:

   - progressive[2] and substantial reductions in radioactive discharges, to the extent needed to achieve the expected sectoral outcomes set out in detail in part 2, whilst taking into account the uncertainties described at chapter 6;

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[1] The 1993 Oslo and Paris Convention on the Protection of the Marine Environment of the North East Atlantic

[2] The UK Government interprets "progressive reductions" as a clear reduction over a number of years or a statistically significant difference between one period of years and a subsequent period to indicate a reduction.

- 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;

- progressive reductions in human exposures to ionising radiation resulting from radioactive discharges, as a result of planned reductions in discharges.

5. The Government considers that the unnecessary introduction of radioactivity into the environment is undesirable, even at levels where the doses to both human and non-human species are low and, on the basis of current knowledge, are unlikely to cause harm.

6. The revised Strategy sets out the radiological, environmental and associated principles that the regulatory bodies will apply when setting discharge authorisations. The Government believes that the application of these principles through the regulatory framework will continue to drive the delivery of progressive reductions in discharges, where practicable, in order to meet the OSPAR intermediate objective for 2020. The Government intends to take costs fully into account in determining how to achieve the objective of the OSPAR RSS.[3]

7. The UK Strategy does not set individual site limits for radioactive discharges, but it does describe outcomes at the sectoral level which are expected to be achieved by 2020 and by 2030, and incorporates a strategic framework for addressing radioactive discharges over the next 20 years. It is the responsibility of the relevant regulatory authorities to ensure that Government policy on radioactive substances is implemented, in particular through the setting of limits through granting discharge authorisations under the RSA93.

8. In setting discharge limits, the regulators will have regard to the application of Best Available Techniques (BAT) Best Practicable Means (BPM) and Best Practicable Environmental Option (BPEO). BAT will replace the use of BPM and BPEO in England and Wales, but BPM and BPEO will continue to be used in Scotland and Northern Ireland.

9. This revised Strategy represents the next chapter of what has been an increasingly effective policy to minimise discharges, recognising the benefits of nuclear practices in terms of energy, defence, medical treatments and scientific research. Whilst noting the concerns of some European countries regarding the longer-term impact of some discharges, overall trends in discharges of man-made radionuclides over the last 20 years show large and sustained reductions of the most radiologically significant radionuclides, particularly from the nuclear fuel reprocessing sector.

10. The scope of the Strategy encompasses radioactive discharges from nuclear licensed sites, defence activities and other nuclear and non-nuclear sources of radioactive discharges. This will provide greater regulatory coherence.

[3] Detailed requirements for achieving the OSPAR objective are set out in the Programme for the More Detailed Implementation of the OSPAR Strategy with Regard to Radioactive Substances, agreed at the OSPAR Commission meeting in June 2000 at Copenhagen.

11. The UK Strategy sits within a well-established framework for the control of radioactive discharges and radiation exposure, comprising national legislation, policy and regulatory arrangements and international commitments and codes of practice. In parallel with this Strategy, the UK Government and the devolved administration for Scotland have issued statutory guidance to the competent authorities on the regulation of radioactive discharges to the environment.

12. The Scottish Government's statutory guidance to the Scottish Environment Protection Agency (SEPA) was published in Spring 2008, following an earlier consultation. The Guidance to the Environment Agency, in relation to England and Wales, will be published by the Autumn 2009. An impact assessment has been completed that evaluates the costs and benefits of move to Best Available Techniques (BAT) in England and Wales.

13. Discharges from five nuclear sectors are considered in the strategy: nuclear fuel production and uranium enrichment, nuclear energy production, spent fuel reprocessing, research facilities and defence facilities. Discharges from the non-nuclear sectors are also discussed. For each sector, the possibilities for reducing discharges are examined and projected discharge profiles for the period 2009 to 2030 are given for the nuclear sectors and for isotope production and the oil and gas sector. Expected outcomes have been set for discharge reductions, by sector.

14. The Strategy's expected outcomes and forward discharge profiles are based on current assumptions about future activities in each sector and we recognise that they will need to be adjusted if assumptions change. In particular, the UK Government has opened the way to new-build nuclear power stations, the potential discharges from which cannot yet be accurately quantified and are not included in the current discharge profiles. This and other uncertainties, (for example further life extensions), are discussed in chapter 6.

15. Based on what energy companies have said, it is possible a programme of new nuclear build could exceed current generating capacity during the timeframe covered by this Strategy. On the basis of the low levels of discharges from current Light Water Reactors (LWRs) in the UK and abroad, such a programme, on a purely illustrative basis, would not prevent the UK from achieving the objective of the OSPAR RSS.

16. The UK Government intends to review this Strategy, its objectives and discharge profiles, about every five years. The review process will take account of developments in UK Government policy, commercial decisions within the nuclear industry, technological advances and improvements in our knowledge of the impacts of radionuclides in the marine environment.

Part 1: Policy, principles & progress to date

Chapter 1 - Introduction and Background

1.1 Radioactive discharges

1.1.1 Radioactive materials are in daily use in the UK. They have many applications, from the generation of electricity to diagnostic tools in medicine. In the course of their use small quantities of radioactive substances may be discharged into the environment, both from nuclear licensed sites and from non-nuclear operators such as universities and hospitals Discharges are in the form of gases, mists, dusts or liquids. The operators of these sites must apply to their environmental regulator for an authorisation to discharge such wastes. These authorisations set strict limits where appropriate, in line with the regulators' own limit setting criteria, on the discharges that may be released from any site. All radioactive discharges are subject to the requirement that the discharges and their impacts are minimised using Best Available Techniques (BAT[4]) in England and Wales or Best Practicable Means (BPM) and Best Practicable Environmental Options (BPEO) in Scotland and Northern Ireland.

1.1.2 In the UK, these discharges are regulated under the RSA93, to ensure that dose levels to members of the public remain well within internationally agreed limits and to protect both human health and the environment.

1.2 OSPAR

1.2.1 The OSPAR Convention for the Protection of the Marine Environment of the North East Atlantic was agreed in 1992. Countries that have either a North East Atlantic coast or discharge into the OSPAR maritime area via their rivers are Contracting Parties to the Convention. Environment agencies in the UK have a duty to implement the general requirements of the OSPAR Convention.

1.2.2 At the 1998 Ministerial meeting of the OSPAR Commission, the Contracting Parties agreed a strategy with regard to radioactive substances (see Box 1).

[4] In the UK the standards required by BAT are considered to be delivered through BPM and BPEO. However, in England and Wales it has been decided to use BAT as this brings the terminology used in to line with that used in the EC.

Box 1: OSPAR Radioactive Substances Strategy (RSS)*

Overall objective:
To prevent pollution of the maritime area, as defined under the Convention, from ionising radiation, through progressive and substantial reductions of discharges, emissions and losses of radioactive substances. The ultimate aim is to achieve concentrations in the environment near background values for naturally occurring radioactive substances and close to zero for artificial radioactive substances. In achieving this objective, the following issues should, inter alia, be taken into account:

- legitimate uses of the sea;
- technical feasibility;
- radiological impacts to man and biota.

Intermediate objective (2020):
By the year 2020, the OSPAR Commission will ensure that discharges, emissions and losses of radioactive substances are reduced to levels where the additional concentrations in the marine environment above historic levels, resulting from such discharges, emissions and losses, are close to zero.

* Radioactive Substance Strategy of the OSPAR Commission for the Protection of the Marine Environment of the North East Atlantic, 1998.

1.2.3 Each Contracting Party was required to produce a national plan to demonstrate how it would achieve the strategy objectives. The OSPAR Commission monitors progress in achieving the strategy through the assessment of national plans for meeting the 2020 objective and through evaluation of actual discharges, environmental concentrations and doses.

1.2.4 The UK's 2002 Strategy for Radioactive Discharges comprised a national plan for the purposes of OSPAR. In 2003, OSPAR concluded that, provided the national plans of Contracting Parties were implemented as forecast, discharges, emissions and losses would be reduced. However, at that stage it was not possible to make a final assessment on whether or not the combined effects of the national plans would be sufficient to achieve the objectives of the OSPAR Radioactive Substances Strategy (RSS) , to the extent required by 2020.

1.2.5 OSPAR has carried out two periodic evaluations of the progress of all Contracting Parties in achieving its RSS, relating to discharges[5] (2006) and to concentrations and resulting doses[6] (2007). These compare baseline data (the mean of measured values for the period 1995 to 2001) with discharge data for 2002 to 2004 and concentration/dose data for 2002 to 2005, using statistical tests. Although there was some evidence of reductions in both discharges and concentrations, the general conclusions were that, given the small number of years since the baseline period, it could not at that time be

[5] Revised first periodic evaluation of progress towards the objective of the OSPAR Radioactive Substances Strategy. OSPAR Commission, 2006.
[6] Second periodic evaluation of progress towards the objective of the OSPAR Radioactive Substances Strategy. OSPAR Commission, 2007.

said with statistical certainty whether the aims of the OSPAR RSS were being delivered. A third periodic evaluation is due to be published later in 2009.

1.3 A Strategy for Radioactive Discharges

1.3.1 In 2002[7] the Government published a strategy document to meet the UK's obligations under the OSPAR Convention. These include a specific commitment on reducing concentrations of radioactive substances in the marine environment by 2020. Ministers agreed to review the initial Strategy after a few years of operation, and this document is the revised Strategy which we believe will help the UK to meet the 2020 commitment. It also provides an updated statement of policy and a framework for discharge reductions until 2030. In a number of areas it differs from the previous Strategy. These changes are detailed in paragraph 1.5.1.

1.3.2 The 2002 Strategy for Radioactive Discharges was written in the context of a declining nuclear industry in the UK and reductions in discharges were largely driven by the assumed closure dates of facilities at that time, consistent with operational planning and safety. Current expectations are that nuclear generating capacity from existing power stations will be required for longer and the UK Government believes that new nuclear power stations should have a role to play in this country's energy mix alongside other low-carbon sources. The challenge of this revised Strategy will be to deliver the UK's commitments to OSPAR in a way that does not compromise UK energy policy.

1.4 UK Strategy for Radioactive Discharges 2001-2020

1.4.1 In addition to being the UK's national plan for meeting the objectives of the OSPAR strategy, the first UK Strategy for Radioactive Discharges established a clear policy base for future reviews of discharge authorisations by the environmental regulators and for strategic planning by the nuclear operators.

1.4.2 The 2002 Strategy covered liquid radioactive discharges from nuclear licensed sites, defence facilities and "other sources of discharges", including non-nuclear industries, such as for medical applications. Its focus was on liquid discharges to sea from coastal nuclear installations, on the assumption that, in general, these would have the largest and most measurable effects in the marine environment.

1.4.3 For each of the nuclear sectors (named in paragraph 5.2.1), the 2002 Strategy set a number of targets for the reduction of liquid discharges. Of these targets, three related to the period 2002 to 2010 and two of these have already been met. A detailed evaluation of progress in delivering the 2002

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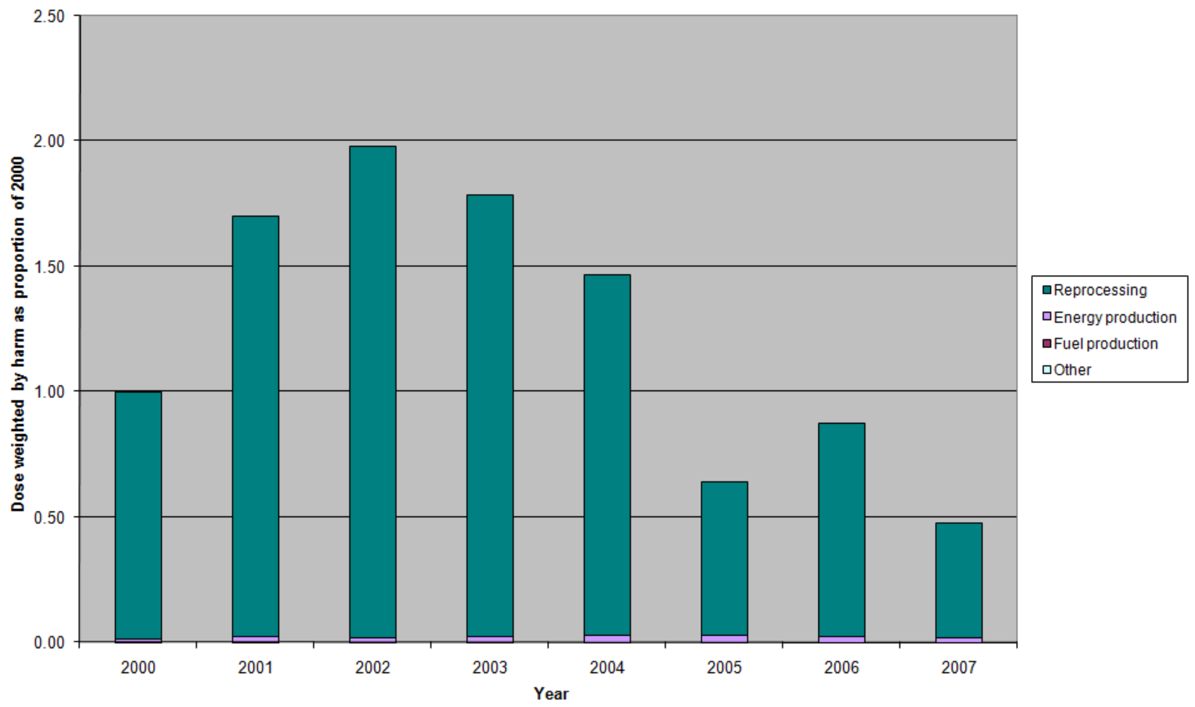
[7] UK strategy for radioactive discharges 2001-2020. Department for the Environment, Food and Rural Affairs, 2002.

Strategy is given at Chapter 5. In common with the 2002 Strategy no targets have been set for the non-nuclear sector in the revised Strategy.

1.4.4 Looking at dose from the total radioactive discharges to water (weighted by harm) when compared with the weighted dose in 2000[8], Figure 1.1 also shows an encouraging picture. Since 2002 there has been a steady downward decrease.

[8] This has been calculated using the "dose per unit release" methodology

Figure 1.1 – Dose (resulting from radioactive discharges to water) weighted by harm as a ratio of dose in 2000 for England, Wales & Scotland



*This graph assumes that all discharges are released into the same environment. The total discharge of each radionuclide from each sub-sector is multiplied by a specific 'dose per unit release' factor which takes into account the different toxicities of different radionuclides and the likely concentration in the environment. The total is then compared to the 2000 total and hence the graph does not have any units. This does not equate to actual impact. The 'other' category includes the research, defence, medical and bioscience, and waste management sub-sectors – they are not shown separately because the contribution they make to the total is so small.
Source: Environment Agency & Scottish Environment Protection Agency

1.5 Scope of the revised Strategy for Radioactive Discharges

1.5.1 In order to meet the OSPAR deadline for national plans, the first UK Strategy for Radioactive Discharges limited itself to considering liquid discharges and dealt mainly with nuclear fuel cycle operations. The revised Strategy has now been expanded beyond the delivery of those commitments made under the OSPAR Radioactive Substances Strategy (RSS), such that its scope now includes:

- liquid and aerial discharges, from nuclear and non-nuclear sources[9]
- separate forward profiles for discharges from decommissioning;
- discharges from radioactive waste management and disposal;
- discharges of naturally occurring radioactive material (NORM); and

[9] In the oil and gas sector these liquid discharges might include suspended particles of solid radioactive scales, sand or sludge etc. The Government expects such discharges to be tightly controlled in accordance with the principles set out in this document.

- discharges from the medical and radionuclide manufacturing sectors.

1.5.2 Expanding the scope of the Strategy in this way is intended to set out a comprehensive picture of radioactive discharges in the UK and a common set of principles to underlie their regulation.

1.5.3 The objectives of this revised Strategy are:

- to implement the UK's obligations, rigorously and transparently, in respect of the OSPAR RSS intermediate objective for 2020; and
- to provide a clear statement of Government policy and a strategic framework for discharge reductions, sector by sector, to inform decision making by industry and regulators.

1.5.4 By working towards these objectives and taking into account the environmental, social and economic considerations set out in chapter 3, the outcomes expected of this Strategy will be:

- progressive and substantial reductions in radioactive discharges, to the extent needed to achieve the sectoral outcomes set out in detail in part 2, whilst taking into account the uncertainties described at chapter 6;
- 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;
- progressive reductions in human exposures to ionising radiation resulting from radioactive discharges, as a result of planned reductions in discharges.

1.6 Principles underpinning the Strategy

1.6.1 Government policy recognises that the unnecessary introduction of radioactivity into the environment is undesirable, even at levels where doses to humans and other species are low and, on the basis of current knowledge, are unlikely to cause harm. Activities involving ionising radiation are subject to the following controls:

- justification[10] of practices by the Government to ensure that the environmental, social and economic benefits they provide to society exceed the potential detriment resulting from them;
- 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), social and economic factors being taken into account;

[10] Justification is a process whereby a case must be made to Government for any new types of radioactivity involving exposure to radioactive substances http://defraweb/environment/radioactivity/government/legislation/justification.htm

- application of limits and conditions to control discharges from justified activities to ensure that individuals (workers and members of the public) and sensitive environmental receptors are not exposed to unacceptable radiation risks from these practices.

1.6.2 In addition, this Strategy is based on the following principles:

- sustainable development, meeting the needs of the present without compromising the ability of future generations to meet their own needs and achieving the optimum balance in environmental, social and economic outcomes, more detail is provided in Chapter 3;
- the use of Best Available Techniques (BAT) in England and Wales to prevent and, where that is not practicable, minimise waste generation and discharges to the environment (see Box 2). The application of BAT is equivalent to Best Practicable Means (BPM) and Best Practicable Environmental Option (BPEO), as described in the 2002 Strategy. BPM and BPEO will continue to be applied in Scotland and Northern Ireland;

Box 2: BAT

The OSPAR RSS requires Contracting Parties to apply BAT[i], together with the polluter pays and precautionary principles, in order to achieve its overall objective (Box 1). Until recently, the concept of BAT has been given effect in the UK through the application of BPM[ii] and BPEO[iii], which the UK believes together achieve an equivalent level of environmental protection to BAT.

The Environment Agency of England and Wales will, in future, be replacing BPM and BPEO with BAT to regulate the discharge of radioactive substances. A move to this approach will deliver a regime that is more consistent with the terminology of the OSPAR Strategy and other environmental protection regimes, including the Integrated Pollution Prevention Control regime. The application of BAT will deliver the equivalent level of environmental protection as achieved until now by the use of BPM and BPEO.

SEPA and the Northern Ireland Environment Agency (NIEA) intend to continue applying BPM and BPEO in the regulation of radioactive discharges in Scotland and Northern Ireland.

For clarity BAT involves both the requirement, where relevant, to select through a systematic and consultative decision making procedure, the option that provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as in the short term. It is implemented in a way which minimises the release of radioactivity, taking a range of factors including cost-effectiveness, technological status, operational safety and social and environmental factors into consideration.

Where an operator is using the range of techniques which represent "BAT" they will have optimised their practice and hence reduced exposure of ionising radiation by the public and the population as a whole to as low as reasonably achievable, taking into account economic and social factors (ALARA principle).

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[i] BAT is a term defined in the OSPAR Convention and European Council Directive 96/61/EC on Integrated Pollution Prevention and Control (IPPC). These definitions are essentially the same. OSPAR: BAT means the *latest stage of development (state of the art) of processes, of facilities, or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste*. *For a particular process, BAT will change with time in the light of technological advances, economic and social factors, as well as changes in scientific knowledge and understanding. If the reduction of discharges and emissions resulting from the use of BAT does not lead on environmentally acceptable results, additional measures have to be applied. "Techniques" include both the technology used and the way in which the installation is designed, built, maintained, operated and dismantled.* Council Directive 96/61/EC: BAT is the most effective and advanced stage in the development of activities and their methods of operation which indicates the practicable suitability of particular techniques for providing the basis for emission limit values designed to prevent, and where that is not practicable, generally to reduce emissions and the impact on the environment as a whole.

[ii] Within a particular waste management option, BPM is that level of management and engineering control that minimises, as far as practicable, the release of radioactivity to the environment whilst taking account of a wider range of factors, including cost-effectiveness, technological status, operational safety, and social and environmental factors. (Taken from Review of Radioactive Waste Management Policy (Cm2919), HMG, July 1995.)

[iii] The outcome of a systematic and consultative decision-making procedure which emphasises the protection and conservation of the environment across land, air and water. The BPEO procedure establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as in the short term. (Taken from Royal Commission on Environmental Pollution, 12th Annual Report, 1988.)

- the precautionary principle, that "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation"[11];
- the polluter pays principle, by virtue of which the costs of pollution prevention, control and reduction measures are to be borne by the polluter.
- 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 (BPM/BPEO in Scotland and Northern Ireland) is being applied and worker dose is taken into account (section 3.3).

1.6.3 The Government believes that the application of these principles through the regulatory framework will continue to drive the delivery of progressive reductions in discharges, where practicable, in order to meet the OSPAR intermediate objective for 2020.

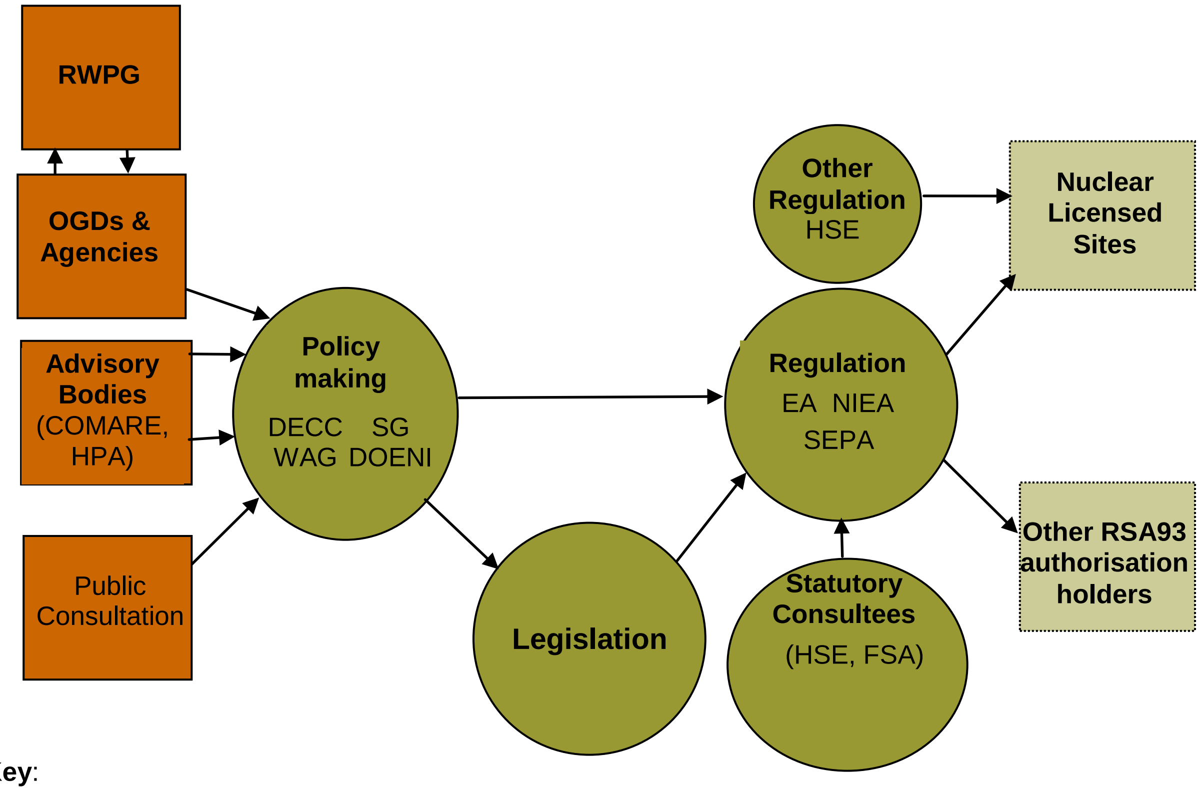
[11] Rio Declaration on environment and development: Annex 1 of Report of the United Nations conference on environment & development. (UN General Assembly, June 1992.)

Chapter 2 - Policy, Legislative and Regulatory Frameworks

2.1 Introduction

2.1.1 The development of Government policy on radioactive waste (including discharges to the environment) and the regulation of discharges by the relevant competent authorities are interrelated as shown in Figure 2.1, below.

Figure 2.1 - Responsibilities for policy development and regulation of radioactive discharges



Key:
COMARE - Committee on Medical Aspects of Radiation in the Environment
DECC – Department of Energy & Climate Change
DOENI - Department of the Environment , Northern Ireland
EA - Environment Agency
FSA - Food Standards Agency
HPA - Health Protection Agency
HSE - Health and Safety Executive
NIEA – Northern Ireland Environment Agency
OGDs - Other Government Departments
RSA93 - Radioactive Substances Act 1993
RWPG - Radioactive Waste Policy Group
SEPA - Scottish Environment Protection Agency
SG – Environmental Quality Directorate of the Scottish Government
WAG - Welsh Assembly Government

2.1.2 **Government Departments:** The responsibility for radioactive waste policy is devolved and the relevant Departments are: DECC in England, the

Environmental Quality Directorate of the Scottish Government, Department of Environment Sustainability and Housing of the Welsh Assembly Government, and Department of the Environment in Northern Ireland. Although the UK, as a single unitary state, retains ultimate responsibility for compliance with international conventions and European Union (EU) legislation, the devolved administrations are responsible for detailed implementation and compliance in their respective countries, so far as these relate to devolved matters. In addition, the Food Standards Agency (a non-Ministerial Government department) has responsibility for all aspects of food safety and is consulted on the setting of authorisations for radioactive discharges. It also has a substantial role in monitoring the marine and terrestrial environment.

2.1.3 **Regulators:** The relevant regulatory authorities ensure that Government policy is implemented. These authorities are the Environment Agency in England and Wales, SEPA in Scotland, NIEA in Northern Ireland and the Nuclear Installations Inspectorate (NII) of the Health and Safety Executive (HSE). The NII regulates the storage and accumulation of radioactive waste on nuclear sites throughout the UK in respect of its production, treatment and storage.

2.1.4 **Agencies:** The Radiation Protection Division of the Health Protection Agency (HPA) (formerly the National Radiological Protection Board (NRPB)) has responsibility for providing information and advice on protection from radiation risks, and for undertaking research to advance knowledge about protection from these risks.

2.1.5 **Advisory Bodies:** The Committee on Medical Aspects of Radiation in the Environment (COMARE) is an independent expert advisory committee, which offers independent advice to Government. The committee is responsible for assessing and advising on the health effects of natural and man-made radiation and assessing the adequacy of the available data and advising on the need for further research.

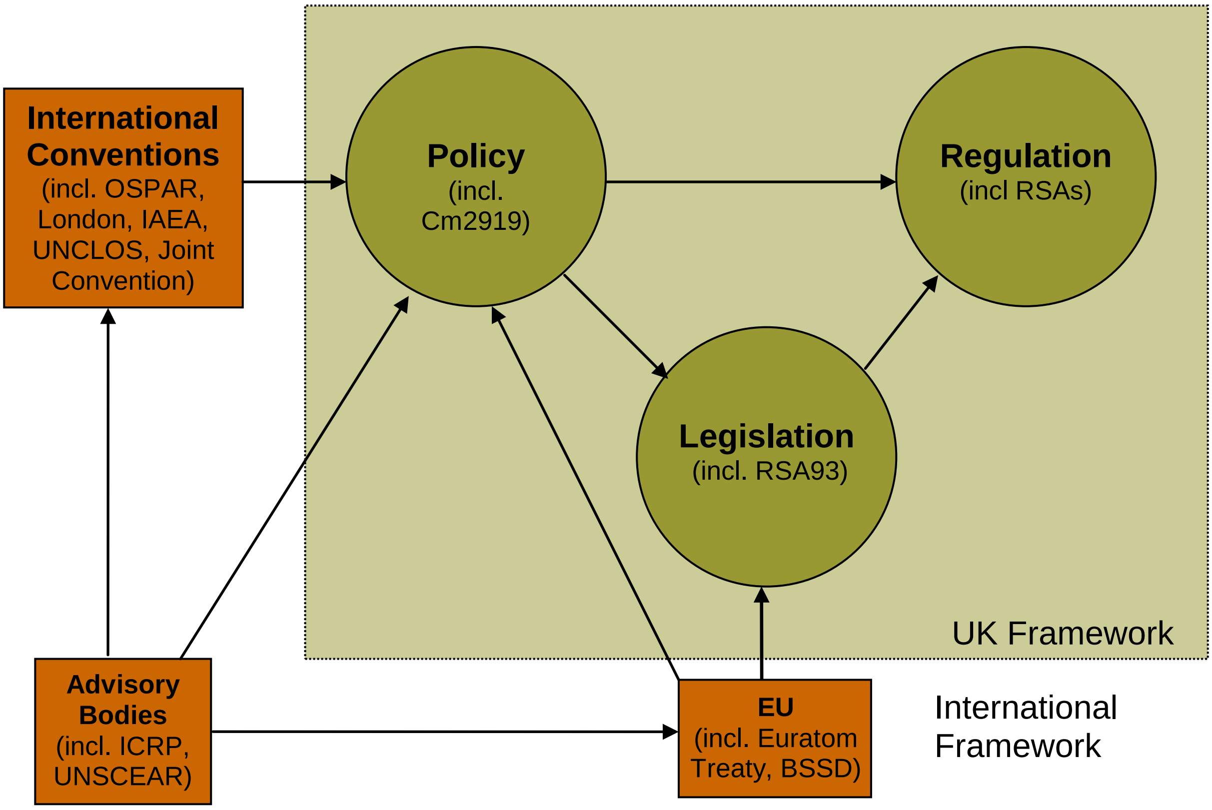
2.1.6 The Radioactive Waste Policy Group (RWPG) reviews and makes recommendations to the Government on issues that arise in relation to radioactive waste management policy, radioactive discharges and associated regulatory processes and arrangements. The group is formed of Government departments, the devolved administrations, the Nuclear Decommissioning Authority (NDA) (see chapter 4) and the principal regulatory bodies (HSE and the environment agencies). Further information on RWPG's activities can currently be found on the following website:

http://defraweb/environment/radioactivity/waste/rwpg/index.htm.

2.2 International context

2.2.1 The UK and international framework within which radioactive discharges are managed is shown in Figure 2.2. There are a number of EU legislative measures, international conventions and advisory bodies, all of which feed into and play an important part in the development of UK policy and legislation on radioactive discharges.

Figure 2.2 - Policy, regulatory and legislative framework for radioactive discharges



Key:
OSPAR - OSPAR Convention for the protection of the marine environment of the North-East Atlantic
London - London Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter
IAEA - International Atomic Energy Agency
UNCLOS - United Nations Convention on the Law of the Sea
Joint Convention - Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
ICRP - International Commission on Radiological Protection
UNSCEAR - United Nations Scientific Committee on the Effects of Atomic Radiation
BSSD - Basic Safety Standards Directive
Cm2919 - Government White Paper on the "Review of radioactive waste management policy", 1995
RSA93 - Radioactive Substances Act 1993
RSAs - RSA93 Authorisations

2.2.2 **Euratom Treaty:** The Euratom Treaty[12] requires compliance with measures to monitor and report radioactivity in the European environment (Articles 35 and 36) and to prevent radioactive discharges or waste disposal in one Member State resulting in the contamination of the environment of another

[12] Treaty establishing the European Atomic Energy Community (Euratom), European Economic Community 1957.

Member State (Article 37). In this context, the European Commission decides whether any plan for the disposal of radioactive waste would result in contamination of the air, water or soil of another Member State that is "significant from the health point of view". Defence sites are not subject to regulation under the Euratom Treaty.

2.2.3 **Basic Safety Standards Directive (BSSD):** European Council Directive 96/29/Euratom (the BSSD) requires Member States of the EU to ensure that all new classes or types of practice resulting in exposure to ionising radiation are justified. An assessment should be undertaken in advance of the practice being first adopted or first approved to demonstrate that its economic, social or other benefits, justify the health detriment it may cause.

2.2.4 Key objectives for radiation protection for members of the public, introduced into UK legislation concurrently with the transposition of the BSSD, require the environment agencies to ensure, wherever applicable, that:

- all public radiation exposures from radioactive waste disposal are kept ALARA, social and economic factors being taken into account;
- the sum of such exposures does not exceed the dose limit of 1 millisievert (mSv) a year;
- the dose received from any new source does not exceed 0.3 mSv a year;
- the dose received from any single site does not exceed 0.5 mSv a year.

2.2.5 **Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management:** Further international controls on radioactive wastes, including discharges, are provided by the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, to which the UK is a Contracting Party. This convention, which entered into force in June 2001, provides for a system of regular peer reviews of the policies and practices of radioactive waste management in each Contracting Party. The UK must provide a national report[13] under the convention every three years for peer review under the auspices of the International Atomic Energy Agency (IAEA), which is an Agency of the United Nations. In addition, the IAEA Radioactive Waste Safety Standards system provides a hierarchy of documents, from broad principles to detailed guidance, on all aspects of radioactive waste management.

2.2.6 **OSPAR Convention:** As stated earlier, the UK is also a Contracting Party to the OSPAR Convention. As a general obligation, OSPAR Contracting Parties shall, in accordance with the provisions of the convention, take all possible steps to prevent and eliminate unnecessary pollution, taking into account BAT, and shall take the necessary measures to protect the maritime

[13] The UK's third national report on compliance with the obligations of the Joint Convention on the safety of spent fuel management and on the safety of radioactive waste management (http://www.defra.gov.uk/environment/radioactivity/government/international/iaea.htm). Defra, May 08.

environment against the adverse effects of human activities in the north east Atlantic. The OSPAR RSS sets objectives and targets for radioactive discharges, which are set out in paragraph 1.3 of this Strategy. In addition, in the 1998 Sintra Statement, Ministers undertook to pay particular attention to the safety of workers in nuclear installations. This Strategy will be presented as the UK's national plan for meeting the commitments of the RSS at the OSPAR Ministerial meeting in 2010.

2.2.7 **London Convention:** The Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter 1972 (the London Convention) regulates dumping at sea. A 1993 Resolution under this convention banned the sea disposal of low level radioactive waste and, together with earlier resolutions, effectively imposed a complete ban on the sea dumping of all radioactive waste. The UK took a decision in 1982 to discontinue sea disposal operations. Operational discharges to sea from land-based installations and offshore platforms are not covered by the London Convention.

2.2.8 **United Nations Convention on the Law of the Sea (UNCLOS):** UNCLOS, 1982, requires contracting parties to take necessary measures to ensure effective protection of the marine environment from harmful effects that may arise from exploration for or exploitation of resources on or under the seabed. It also requires ships carrying nuclear cargoes through the territorial sea to carry documents and observe special precautionary measures established in international agreements regarding such transports.

2.2.9 **International Commission on Radiological Protection (ICRP):** UK policy on the control of radiation exposure has long been based upon acceptance of the recommendations of the appropriate international bodies. The ICRP has recommended a system of radiological protection based on the principles of justification of activities involving ionising radiation, optimisation of protection and dose limitation. Further recommendations have built on this system and have introduced the use of dose constraints and risk constraints.

2.2.10 **United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR):** UNSCEAR was established by the General Assembly of the United Nations in 1955. Its mandate is to assess and report levels and effects of exposure to ionising radiation. UNSCEAR reports are used by the international community as principal sources of information and as the scientific basis for evaluating radiation risk and for establishing protective measures.

2.3 UK context

2.3.1 **Policy**: In 1995, the Government published a White Paper, Cm2919[14], which set out the conclusions of the then UK Government's review of radioactive waste management policy. Since then, some of the policy statements have

[14] Review of Radioactive Waste Management Policy (Cm2919). HM Government, July 1995.

been superseded, such as those on the management of low level radioactive waste[15].

2.3.2 **RSA93:** RSA93, as amended by the Environment Act 1995 and by legislation implementing the BSSD, is the formal basis for control of radioactive disposals (including discharges), and other aspects of the control of radioactive materials in the UK. It provides a framework for standards, practices and objectives in the field of radioactive waste management articulated in Government policy statements. The Act sets out requirements for registration (relating to the use of radioactive material) and authorisation (for the disposal and accumulation of radioactive waste). It prohibits any disposal of radioactive waste other than in accordance with the conditions of an authorisation granted by the appropriate regulatory body. Radioactive discharges and emissions to the environment are considered to be disposals of radioactive waste under RSA93.

2.3.3 Certain categories of activities are specified in Exemption Orders (EOs) under the RSA93 and are not subject to its requirements, although most of the Exemption Orders have conditions attached. EOs may apply to certain activities relating to natural radioactivity, to certain products containing radioactivity (such as smoke detectors) or to specific activities (such as the use of radioactivity in hospitals and schools). Although such activities are minor contributors to the national picture of radioactive discharges, it is still expected that best practice to reduce radioactive discharges will be used wherever practicable.

2.3.4 Ministry of Defence (MoD) sites are excluded from statutory regulation under RSA93, although the environmental regulators exercise an equivalent system of controls by administrative means. Statutory regulation is, however, applied to the licensed sites at the Atomic Weapons Establishments (AWE) at Aldermaston and Burghfield and to the Royal Dockyards at Devonport and Rosyth, which are operated by civilian contractors. The Defence Nuclear Safety Regulator **(**DNSR) is the MoD regulator for nuclear and radiological safety and environmental protection in the defence nuclear programmes, with a primary focus on regulating those aspects of the defence nuclear programmes that are exempt from legislation. DNSR works closely with the relevant statutory regulators.

2.3.5 **Nuclear Installations Act 1965 (NIA 65):** The NIA 65 requires sites where specific nuclear activities are undertaken to be licensed by the HSE. The NII within the HSE's Nuclear Directorate regulates the storage and accumulation of radioactive waste on these nuclear licensed sites.

2.3.6 **Occupational exposure legislation:** Occupational exposure to ionising radiation and any direct exposure to other persons arising from a work activity are regulated by the HSE under the Health and Safety at Work Act 1974 and the Ionising Radiations Regulations 1999. Similar regulations are enforced by the HSE, Northern Ireland.

[15] Policy for the Long Term Management of Solid Low Level Radioactive Waste in the UK, March 2007.

2.3.7 **Regulation:** It is not the function of this Strategy to prescribe individual site limits for radioactive discharges, but rather to indicate the strategic direction. The environment agencies have responsibility for issuing authorisations for radioactive discharges under RSA93 and for varying existing authorisations. Their radioactive substances regulation environmental principles (REPs) underpin their decisions including those in relation to permitting and compliance.

2.3.8 Statutory Guidance to the Environment Agency in England and Wales and separate Statutory Guidance issued to SEPA, provide the vehicle through which this Strategy will be implemented. The Guidance sets out a clear framework within which the environment agencies will operate when authorising the discharge of radioactivity into the environment. It makes clear that, when granting discharge authorisations, the environment agencies should seek to ensure that they are consistent with this Strategy and the principles that underpin it (see section 1.6). In Northern Ireland the Department of the Environment will request the Chief Inspector to ensure that discharge authorisations which they may grant are consistent with this Strategy.

2.3.9 **Better Regulation**: The Government considers that this Radioactive Discharges Strategy is consistent with the five principles of better regulation, namely proportionality, accountability, consistency, transparency and targeting. It is also consistent with principles for the way that regulators should discharge their duties, set out in the Hampton Report[16], the Legislative and Regulatory Reform Act 2006[17] and the Compliance Code[18] which came into force in April 2008. This Strategy looks to achieve its objectives with minimum regulatory burden, taking on board the recommendations of the Better Regulation Executive.

[16] Reducing administrative burdens: effective inspection and enforcement. Philip Hampton, March 2005.
[17] Legislative & Regulatory Reform Act 2006, HMSO 2006
[18] SI 2007 No. 3548 The Legislative & Regulatory Reform Code of Practice

Chapter 3 - Achieving a balance

3.1 The need to achieve a sustainable balance

3.1.1 The principal objectives of this Strategy are to implement the UK's obligations in respect of the OSPAR RSS and to achieve progressive and substantial reductions in radioactive discharges. However in working towards the achievement of these objectives we expect the Strategy to also support the achievement of several other Government policies:

- managing waste sustainably;
- decoupling environmental degradation from economic growth;
- cleaner, safer and more biologically diverse seas; and
- improving the quality of river water .

3.1.2 These policies contribute to the priority areas for action contained in the Government's revised strategy for sustainable development, "One Future – Different Paths)"[19] which was published in 2005. This sets out a common framework across the entire UK. The four sustainable priority areas for action up to 2020 are:

- sustainable consumption and production;
- climate change and energy;
- natural resource protection and environmental enhancement; and
- sustainable communities.

Linked to these priority areas is, in many cases, a need to change behaviour and public perception.

3.1.3 The priority areas are underpinned by five guiding principles:

- Living within environmental limits
- Achieving a sustainable economy
- Ensuring a strong, healthy and just society
- Promoting good governance
- Using sound science responsibly

3.2 Sustainable development and radioactive discharges

3.2.1 Sustainable development is defined to be *'development which meets the needs of the present without compromising the ability of future generations to meet their own needs'*. In working towards it an analysis of the environmental, social and economic aspects of sustainable development needs to be carried out and a balance struck when making decisions about the best way to take policy objectives forward. It should be noted that UK research and development supports nuclear industry activities that may result in discharge reductions. In relation to reducing radioactive discharges and achieving a

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[19] Securing the future, delivering the UK sustainable development strategy (Cm6467). HM Government, March 2005.

balance, some flexibility is needed to safeguard other Government objectives. For example:

- In healthcare, balancing the health and economic benefits of radio-pharmaceuticals against the radioactive discharges resulting from their use and manufacture;
- In defence, balancing the national security benefits of maintaining defence operational capability with the radioactive discharges that arise from defence operations and activities;
- In securing the UK's energy supply, as a basic requirement of sustainable development, including potential new nuclear build in England and Wales, and the possibility of extending the operational lives of existing Advanced Gas-cooled Reactor (AGR) nuclear power reactors;
- In the decommissioning and clean-up of nuclear facilities and remediation of contaminated land, balancing the benefits of hazard reduction and environmental restoration against the discharges generated from the processing of radioactive materials and wastes.

3.2.2 Looking at the selection of the most appropriate abatement technology to reduce discharges into the environment shows how the environmental, social and economic aspects of sustainable development need to be balanced.

- There would be no overall benefit to the environment if, as a result of the new abatement process, a plant emitted large quantities of carbon dioxide or toxic (but non-radioactive) substances into the environment, resulting in environmental harm equal to or greater than that avoided by abating the radioactive discharges.
- There is a need to consider whether further discharge abatement represents value for money, recognising that there is a point where the costs of further discharge reduction measures could be disproportionate to the benefits of small reductions in discharges.

The principles and techniques used to achieve this balance are described in section 1.6. It should be noted that the abatement technologies described in this document are those that are being used now or that are planned to be used by operators to reduce emissions. (It should not be read that these abatement technologies have been endorsed by their inclusion in this document. The principle that the operators, not the regulators, are responsible for managing the risks remains.) These technologies are likely to change over time; it is the responsibility of the operators to determine how and when they adopt new abatement techniques and the environment agencies to ensure that operators apply BAT or BPM/BPEO when making these decisions.

3.3 Sustainable development: Environmental considerations

3.3.1 The environmental strand of sustainability involves minimising so far as practicable the UK's impact on the environment with the aim of protecting the Earth's environmental capital. This goal implies that decisions regarding radioactive discharges are made in the light of assessments of different forms of environmental benefits and detriments.

3.3.2 Options for the management of radioactive waste range from direct discharge of gaseous or liquid radioactivity into the environment ('dilute and disperse') to the trapping the radioactivity in a solid, concentrated form for storage and eventual disposal ('concentrate and contain'). The Government's view, in line with guidance from the IAEA[20], is that 'concentrate and contain' should be the generally preferred option for managing radioactive wastes. However, if BAT, or BPM and BPEO in Scotland and Northern Ireland, were to demonstrate that dilute and disperse were to produce a benefit over and above concentrate and contain this option could be considered.

3.3.3 In England, the Government's approach to sustainable waste management[21] is based on the Defra waste hierarchy (Figure 3.2), with similar waste hierarchies (sharing a common philosophy) applying in the Devolved Administrations (Scotland, Wales and Northern Ireland). The waste hierarchy is a cornerstone of the UK's waste management strategy. It should be noted that it is difficult to apply the waste management hierarchy to multi-media discharge/disposals of radioactive and non-radioactive materials.

3.3.4 Radioactive waste should not be created unless the practice giving rise to it has been justified and the generation of waste cannot be avoided. Operators are expected to reduce the quantity of waste and its impact on the environment by careful planning and design and re-using or recycling the materials they use. The energy and materials within waste that cannot be re-used or recycled should be recovered, for instance by generating energy from the waste (such as incineration). Only where these options are not practicable should the waste be disposed of.

3.3.5 The waste hierarchy is already at the heart of the regulation of radioactive and non- radioactive waste, including discharges. The NDA, which is responsible for the decommissioning and clean-up of the UK's civil public sector nuclear legacy (paragraph 4.1.2), requires each of its sites to have an integrated waste strategy based on the principles of the waste hierarchy and sustainable development.[22]

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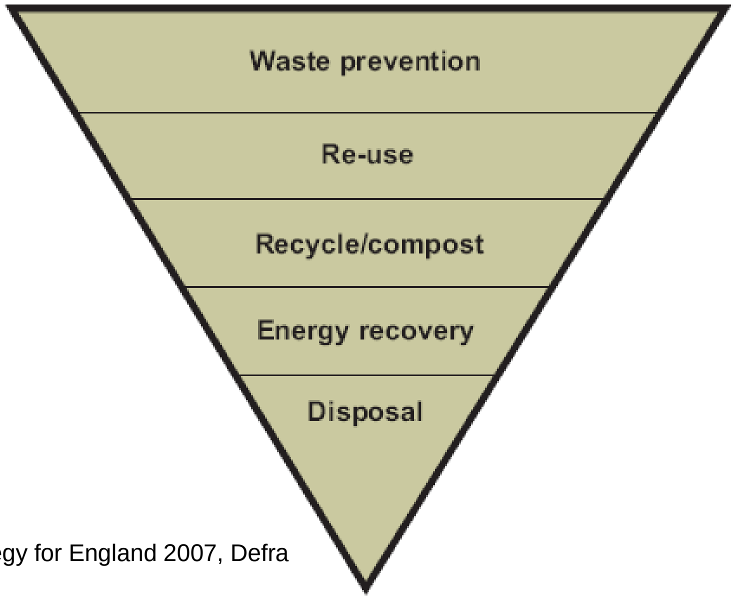
[20] The Principles of Radioactive Waste Management, Safety Series No.111-F. IAEA, 1995.

[21] Government's overall objective for waste policy as set out in Chapter 3 of 'Securing the Future': "Protection of human health and the environment by producing less waste and by using it as a resource wherever possible. Through more sustainable waste management – reduction, re-use, recycling, composting and using waste as a source of energy – the Government aims to break the link between economic growth and the environmental impact of waste".

[22] http://www.nda.gov.uk/documents/upload/WNM-PP-001-The-role-of-the-waste-hierarchy-March-2008.pdf

Figure 3.2 - Waste Hierarchy



Source: Waste Strategy for England 2007, Defra

3.3.6 Other environmental issues which need to be considered include: biodiversity, landscape, soil quality and resource use.

3.3.7 In considering biodiversity, numerous studies are currently being undertaken on the impact of anthropogenic sources of radioactive substances on marine biota. The OSPAR Commission has carried out one such assessment, which it published in 2008[23]. This study concluded that, for the limited set of radionuclides considered, the partial calculated dose rates to marine biota are low and are below the lowest levels at which any effects are likely to occur.

3.3.8 Soil and groundwater quality have been affected by a legacy of leaks of radioactivity from historical operations. Protection of groundwater and land is a priority; historical contamination of groundwater may in some cases be contributing to human exposure to ionising radiation. The Water Framework Directive[24] requires the protection of water bodies in their own right. Further consideration of this issue may need to be undertaken within the next review.

[23] Assessment on impact of anthropogenic sources of radioactive substances on marine biota. OSPAR 2008.

[24] Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy.

3.4 Sustainable development: Societal considerations

3.4.1 One outcome of this strategy is expected to be progressive reductions in human exposure to ionising radiation resulting from radioactive discharges.

3.4.2 There are two groups of people who may be considered to be the most exposed to radiation from artificial sources; those who work with radioactivity (site workers) and those members of the public who are likely to receive the highest radiation dose as a result of a given artificial radiation source (known as the critical group).

3.4.3 Of these two groups site workers are generally exposed to the highest levels of radiation. Doses to employees are limited to 20 mSv/year (or 100 mSv over five years) with lower limits applying to potentially vulnerable groups such as women of child bearing age. The rigorous application of the ALARA principle means that doses are kept well below these limits.

3.4.4 Critical group exposure to radiation is generally far lower than that of workers and results either from exposure to penetrating radiation direct from the site or through exposure to radioactivity discharged to the environment. The dose limit for members of the public is 1 mSv per year and exposure of critical groups is generally a small fraction of this limit. By ensuring that the critical group is not exposed to unacceptable levels of radiation as a result of discharges will result in, the wider population also being protected. Box 3 provides background information on sources and exposure to radiation.

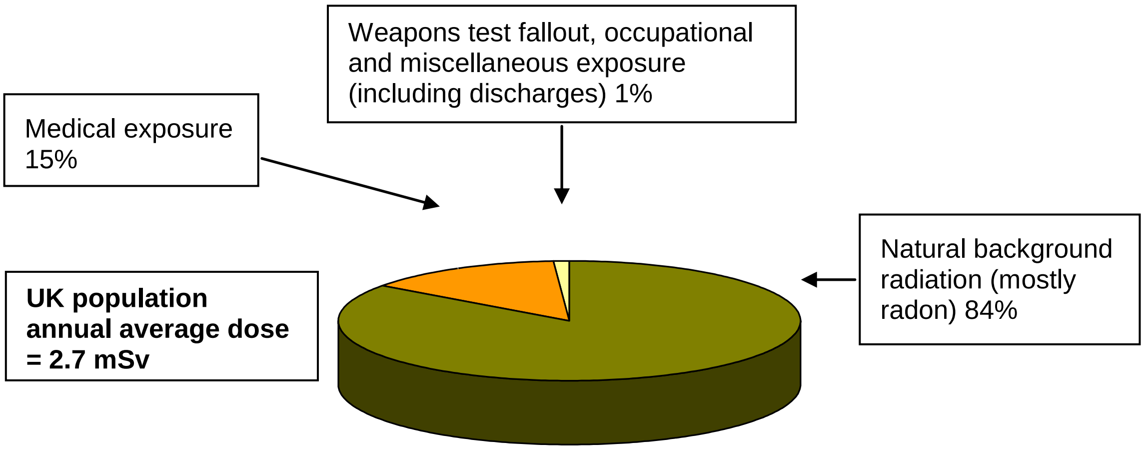
3.4.5 In some situations, some members of the public may be exposed to radioactivity through radioactive discharges as a result of their occupation, even though such exposure is not normally considered to be "occupational". Examples of this are fishermen who may be exposed by handling nets and fishing gear, due to radioactivity adsorbed onto particles of sediment from historic discharges[25], and some workers in sewage treatment plants as a result of body wastes from cancer patients receiving radiotherapy[26].

3.4.6 Retaining on site radioactive waste that would otherwise be discharged to the environment may reduce the dose to the critical group, but can sometimes increase the dose to site workers, potentially by significantly more than the reduction in dose to individuals within the critical group. Equally, reducing liquid discharges by evaporation could increase aerial discharges and result in unacceptable doses to site workers and to local communities.

[25] Radioactivity in Food and the Environment 2007 (RIFE-13). Environment Agency, Northern Ireland Environment Agency, Food Standards Agency and Scottish Environment Protection Agency, 2008.
[26] Investigation of sources and fate of radioactive discharges to public sewers. Environment Agency, 2000.

Box 3: Background information on sources and exposure of radiation

We are all exposed to ionising radiation, most of which is of natural origin. Natural background sources of radiation include cosmic rays from outer space, gamma radiation from the rocks and soils of the earth's crust and radionuclides in foods and in the air that we breathe. The background radiation doses which people receive depend on where they live, their habits and their diet. For the population as a whole, discharges from nuclear installations contribute less than 0.01% to the annual average dose of 2.7 mSv. The main sources of radiation exposure are shown in the pie chart below taken from HPA report, Ionising radiation exposure of the UK population: 2005 review (HPA-RPD-001).



An average member of the public receives less than 0.001 mSv a year as a result of radioactive discharges from all sources. To put this into perspective, it is around one thirtieth of the average annual public dose from air travel, as a result of cosmic radiation. The highest estimated dose from discharges from nuclear sites to a representative member of a critical group in the UK was 0.24 mSv a year in 2007*, as a result of current and historic discharges from Sellafield. Most other sites give rise to doses significantly lower than this.

*Radioactivity in Food & the Environment 2007 (RIFE-13)

3.4.7 It is important to ensure that discharge reductions are not achieved at the expense of unacceptable increased accident risk, due, for instance, to storage of greater quantities of waste on site, for a longer time, in unsatisfactory conditions. The systems of control for nuclear safety and nuclear waste management in the UK would not, in any case, allow the risks from such factors to increase unacceptably.

3.4.8 It is also important to consider the exposures of the population as a whole as well as the most exposed individuals. The collective dose is the sum of doses received by members of the exposed population from all significant exposure pathways from a given source. The collective dose is intended for use as part of the optimisation process, for comparing radiological technologies and protection procedures.

3.5 Sustainable development: Economic considerations

3.5.1 The economic strand of sustainability encompasses developing sustainable economic growth, to maintain quality of life while decoupling such growth from environmental degradation.

3.5.2 The costs of discharge reduction must be taken to include wider economic, societal and environmental detriment, as well as monetary expenditure. Increased industry expenditure is likely to be passed on to customers and/or taxpayers. If plants become economically less viable, they may close, with consequent job losses which in turn could result in impacts on health and wellbeing.

3.5.3 In some cases, where planned closure of the plant is already foreseen, it may not be appropriate to expend great amounts of resource to reduce discharges if they would in any case cease within an acceptable timescale. Similarly, the lead time needed for technological improvements to be put in place needs to be viewed in light of the planned life of the process and an appropriate life cycle assessment.

3.5.4 In addition, where public or private money is spent to achieve reductions in discharges, it is necessary to ensure that the environmental, social and economic benefits of proposals are sufficient to demonstrate that expenditure on reductions represent value for money so that public funds are allocated to where they achieve the most benefit in terms of sustainability and quality of life.

3.5.5 A final impact assessment, which jointly considers both this revised Strategy for Radioactive Discharges and the Statutory Guidance to the Environment Agency in England and Wales on the regulation of radioactive discharges, is at Annex B. This concludes that the additional costs and benefits and regulatory burden involved will be small.

Chapter 4 - Introduction to the UK’s nuclear and non-nuclear industry

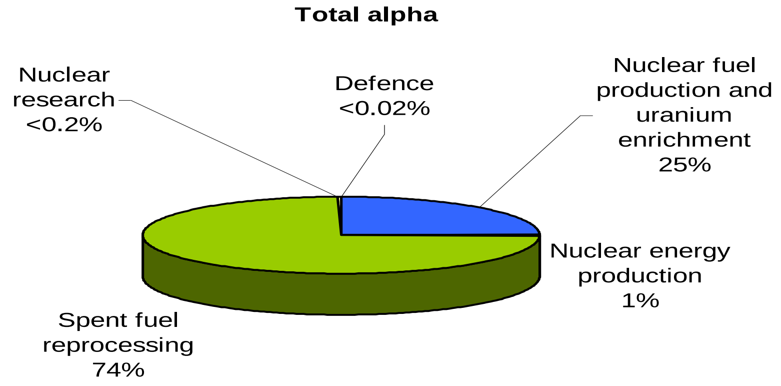
4.1 Nuclear industry

4.1.1 The UK has been engaged in the development of civil nuclear power for over 50 years. The nuclear industry can be divided into five sectors: nuclear fuel manufacture and uranium enrichment, nuclear energy production, spent fuel reprocessing, research facilities and defence facilities. Figures 4.1 to 4.3 show the proportion of radioactivity discharged from each of the nuclear sectors. Chapters 7 to 11 provide an overview of these sectors and their discharges, together with information provided by the operators on abatement technologies and projected discharges to 2030. The locations of the UK's nuclear licensed sites (and main non-nuclear sites) are shown on Map 1. An outline of the nuclear fuel cycle in the UK is shown in Figure 4.4. An explanation of reprocessing is given at Box 4 in Chapter 9.

4.1.2 On 1 April 2005, the NDA was established to provide UK-wide strategic focus on decommissioning and cleaning up the UK’s civil public sector nuclear legacy. Its mission is to deliver safe, sustainable and publicly acceptable solutions to the challenge of nuclear clean-up and waste management. The NDA has responsibility for cleaning up the 19 sites previously owned and operated by British Nuclear Fuels Limited (BNFL) and the UK Atomic Energy Authority (UKAEA), safely, securely and in ways which safeguard the environment. These sites are operated by site licence companies under contract to the NDA.

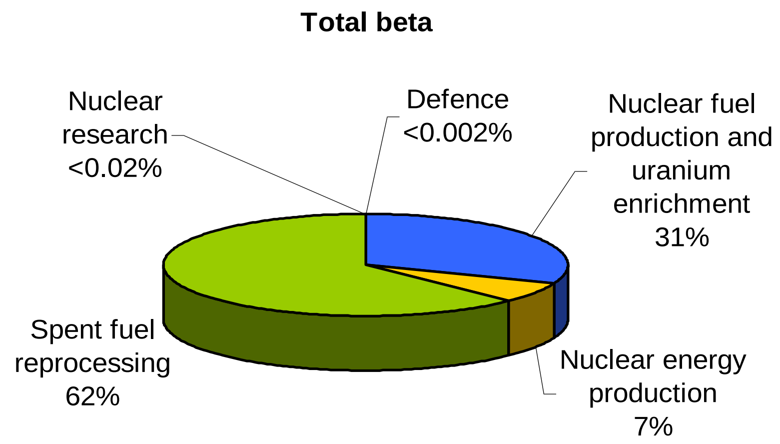
4.1.3 The NDA’s budget of over £8 billion for the three year period from 2008/09 represents the largest amount of expenditure yet allocated to the UK civil nuclear clean-up programme over such a period. However, the NDA has indicated in its three year rolling business plan that, in order to deliver real progress in dealing with the higher hazard facilities, principally those at Sellafield and Dounreay, funding will need to be reprioritised from other areas. It is, therefore, possible that, as a result of such reprioritisation, the timing of some decommissioning operations may be affected. This will have knock-on effects on the timing of discharges resulting from such activities.

Figure 4.1 - Proportion of total-alpha discharges from nuclear sectors, 2006*



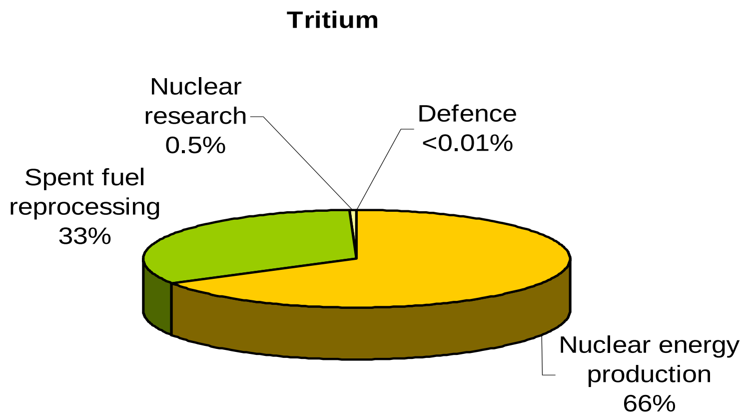
*Inclusive of contributions from decommissioning activities and clean-up of legacy wastes

Figure 4.2 - Proportion of total-beta discharges from nuclear sectors, 2006*



*Inclusive of contributions from decommissioning activities and clean-up of legacy wastes

Figure 4.3 - Proportion of tritium discharges from nuclear sectors, 2006*



*Inclusive of contributions from decommissioning activities and clean-up of legacy wastes

Map 1 - Locations of nuclear licensed and main non-nuclear sites in the UK

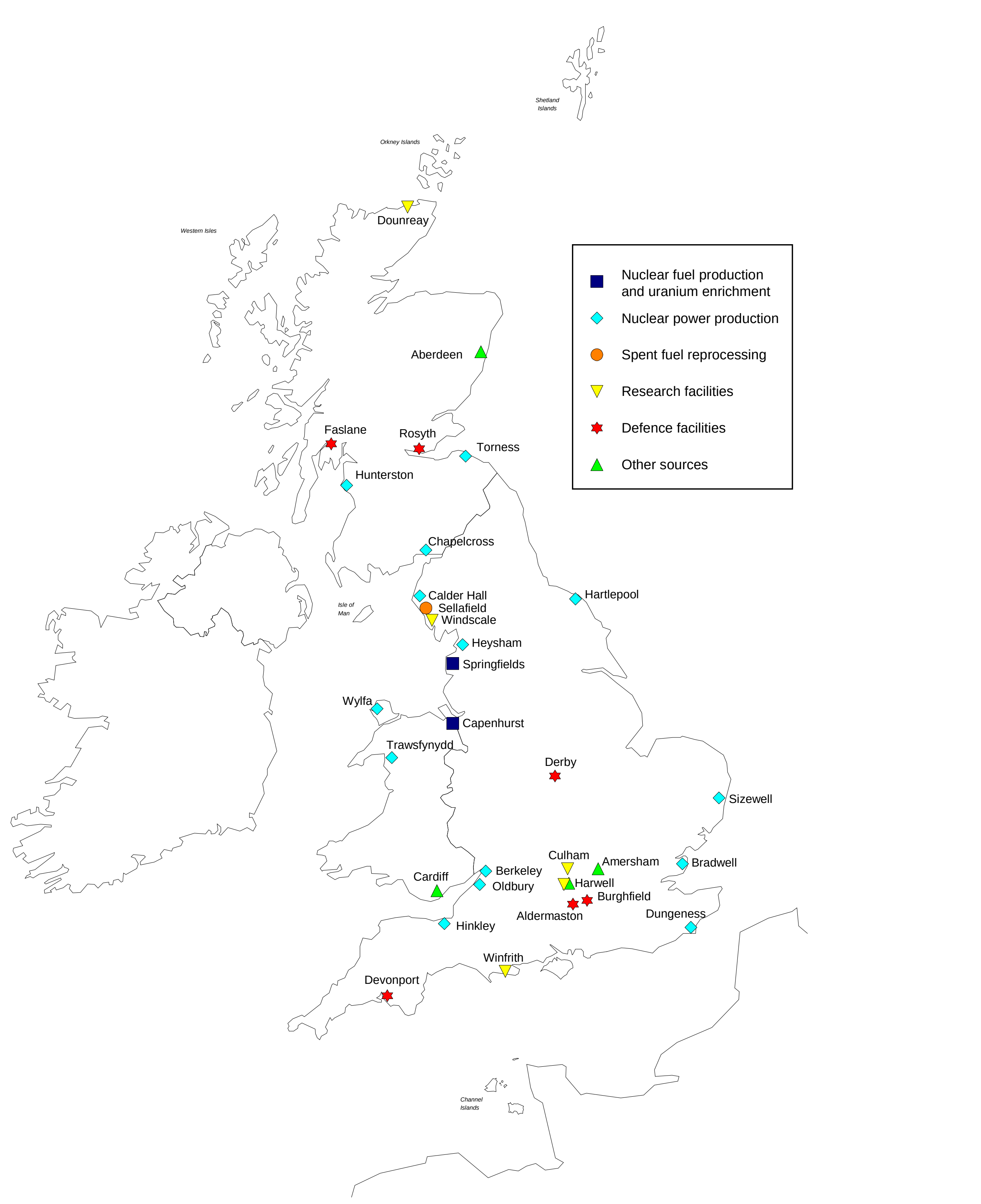
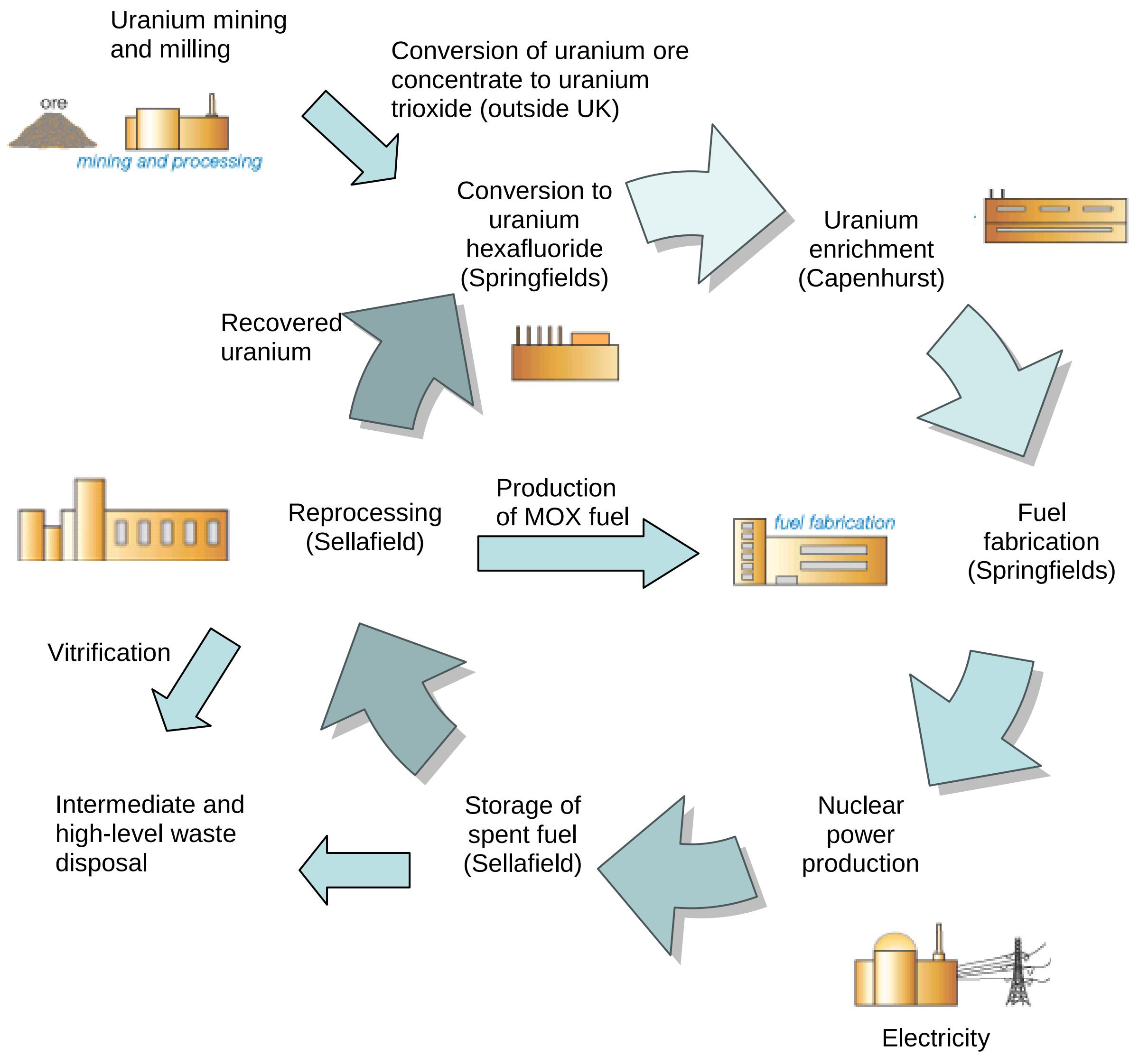


Figure 4.4 - Nuclear fuel cycle



4.2 Non-nuclear industry

4.2.1 Discharges from individual non-nuclear sites tend to be lower than those from nuclear licensed sites; however, there are many more of them and some can lead to significant discharges. Since the publication of the last Strategy, the environmental regulators have started compiling information through the pollution inventories on collective radioactive discharges from non-nuclear activities. With this information, it is now possible to start tracking changes in the pattern of radionuclide discharges and focus on those discharges which are, individually or collectively, the most significant. Since 2004 the UK has provided OSPAR with data on radioactive discharges from the oil and gas and medical non-nuclear industries.

4.2.2 For the purposes of this Strategy, the non-nuclear industry has been divided into the following main categories; oil and gas, medical, radioisotope production, university and research centres, pharmaceutical, and waste sectors. Chapters 12 to 14 provide an overview of these industries and their discharges, together with information on abatement technologies and projected discharges provided by the industry. As described in chapter 11, non-nuclear discharges also arise from defence sites.

Chapter 5 - Evaluation of progress in delivering the UK Strategy for Radioactive Discharges 2001-2020

5.1 Evaluation of progress

5.1.1 This chapter analyses historic trends in liquid radioactive discharges, concentrations in the marine environment and doses, and evaluates the progress that has been made on a sector by sector basis. Discharge profiles have been compared against the discharge projections set out in the 2002 UK Strategy for Radioactive Discharges.

5.1.2 The dose data, weighted by harm, resulting from radioactive discharges to water in England, Wales and Scotland, as compared with weighted by doses in 2000, is shown in Figure 1.1.

5.2 Evaluation of discharges 2001 to 2005

5.2.1 Evaluation of liquid radioactive discharges has been carried out for the period 2001 to 2006 for each of the five nuclear industry sectors; namely nuclear fuel manufacture and enrichment, nuclear energy production, spent fuel reprocessing, research facilities and defence facilities.

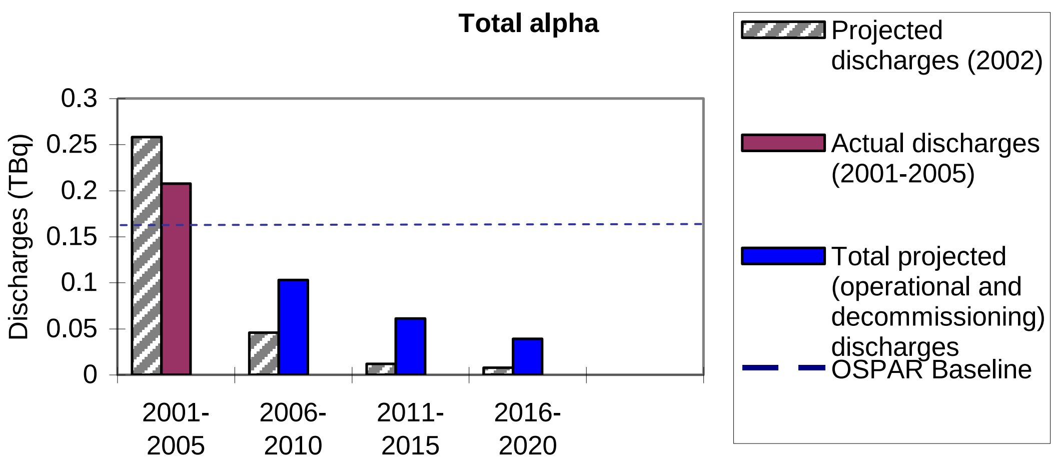
5.2.2 The following graphs (Figures 5.1 to 5.5) compare liquid discharge projections (indicated as hatched grey bars) made in the 2002 Strategy, with actual liquid discharges for the period 2001 to 2005 (indicated as purple bars). Both the projections and actual discharges are shown as five year annualised averages. For subsequent five year periods, the 2002 discharge projections are compared with the revised projections included in this strategy (the solid blue bars).

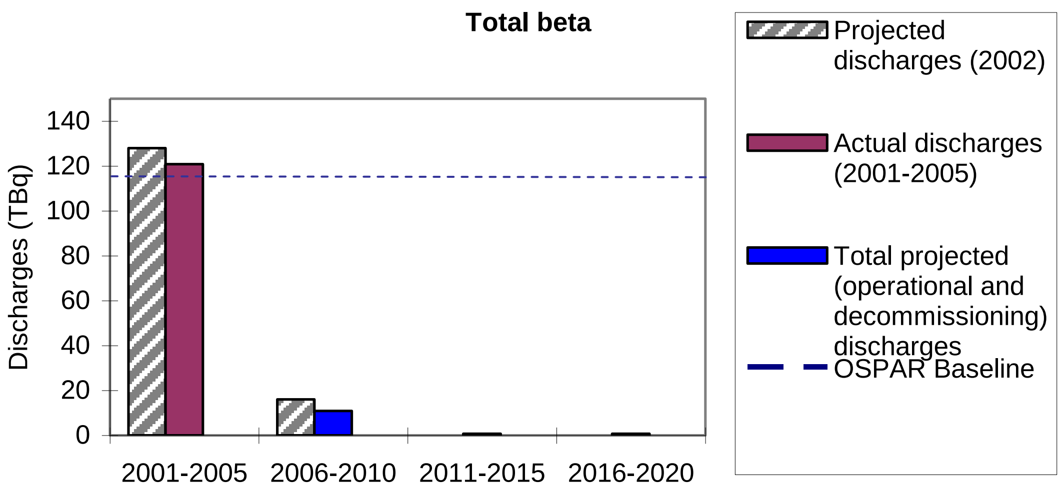
5.2.3 The blue horizontal dotted line shown on some graphs indicates the OSPAR baseline against which the UK's progress in achieving the objectives of the RSS is being assessed. In order to take account of the natural variability of discharges from year to year, the baseline is an average of UK discharges between 1995 and 2001 (seven years which straddle the year 1998, in which the OSPAR Strategy was agreed). OSPAR has established baselines for liquid discharges of total alpha and total beta, but not for tritium. It should be noted that certain radionuclides within these groups can lead to varying levels of radiation exposure. As defence sector discharges are not included within the scope of the OSPAR strategy, no baselines have been assigned to this sector. In some cases actual discharges have been higher than the baseline since 2001 due to operational facilities not being fully utilised for all or part of the baseline period.

5.2.4 In the tables below the graphs, the targets included in the 2002 strategy are summarised, with an indication of whether they have been met or are likely to be met.

5.2.5 **Nuclear fuel production and uranium enrichment**

Figure 5.1 - Fuel production and uranium enrichment sector: evaluation of progress

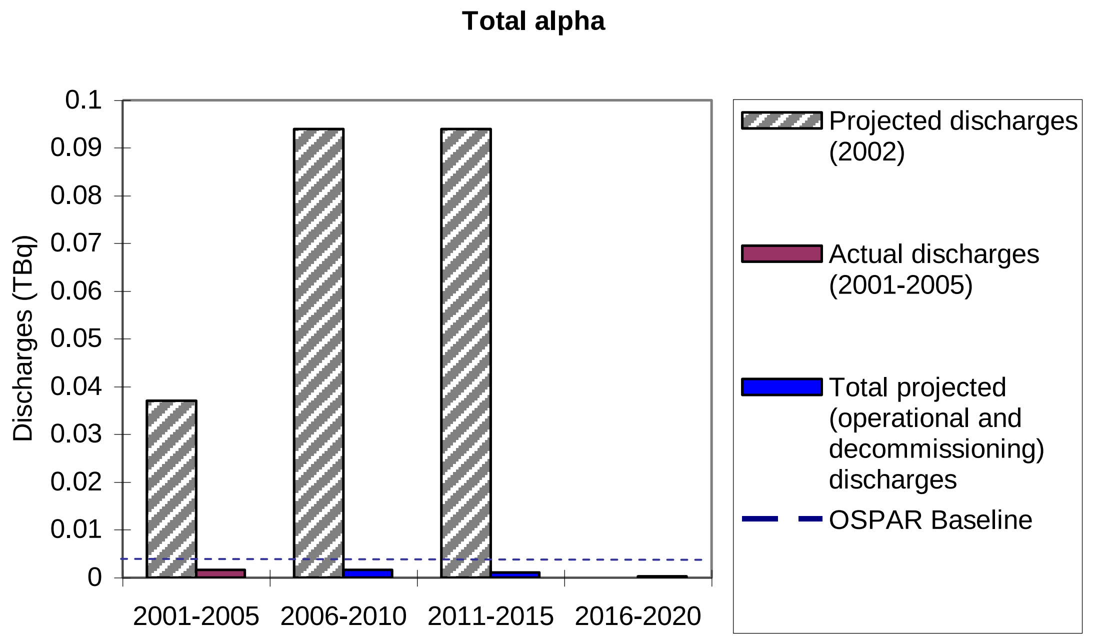




Target date	Target description	Target met?
2001 to 2005	Discharges	Actual in line with projected.
2006	Cease production of Magnox fuel and uranium hexafluoride (UF_6)	Elements of target most relevant to environmental discharges met: uranium ore concentrate processing ceased in 2006 and Magnox fuel production in 2007 (see para 5.2.11 & chapter 7) and resulted in the anticipated significant reduction in discharges being achieved.
2020	Total-β (except tritium (H-3)) virtually zero, total-α <0.01 Terabecquerels (TBq)/yr	Current lifetime plan assumptions indicate that total-β discharges will be <0.7 TBq/yr and total-α <0.04 TBq/yr

5.2.6 Nuclear energy production sector

Figure 5.2 - Nuclear energy production sector: evaluation of progress



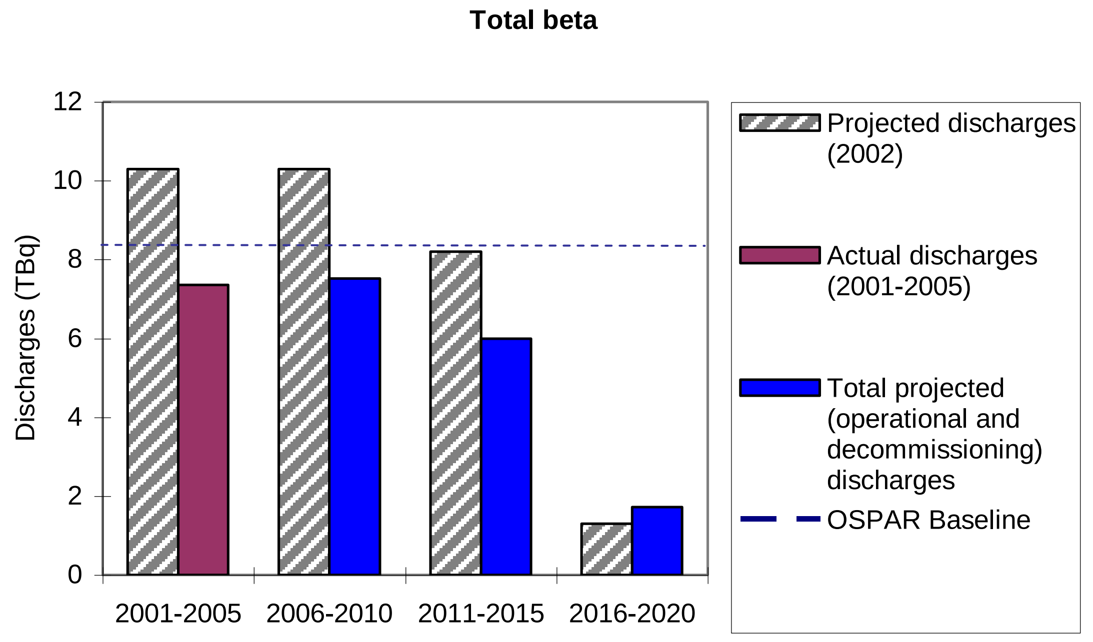
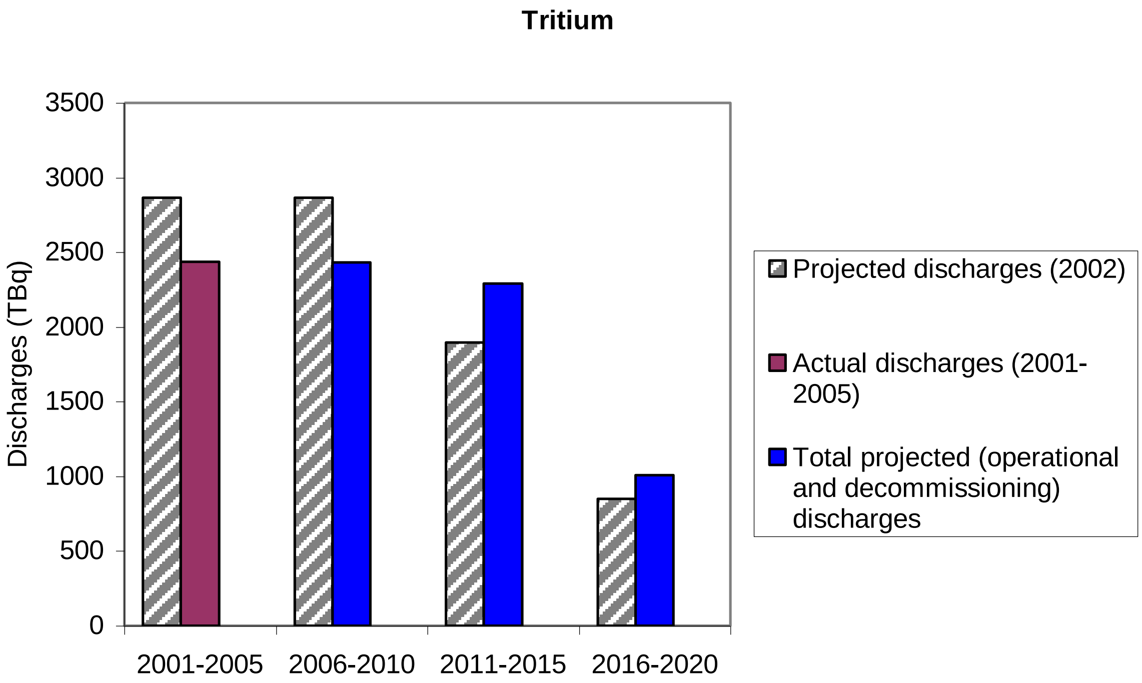


Figure 5.2 - Nuclear energy production sector: evaluation of progress

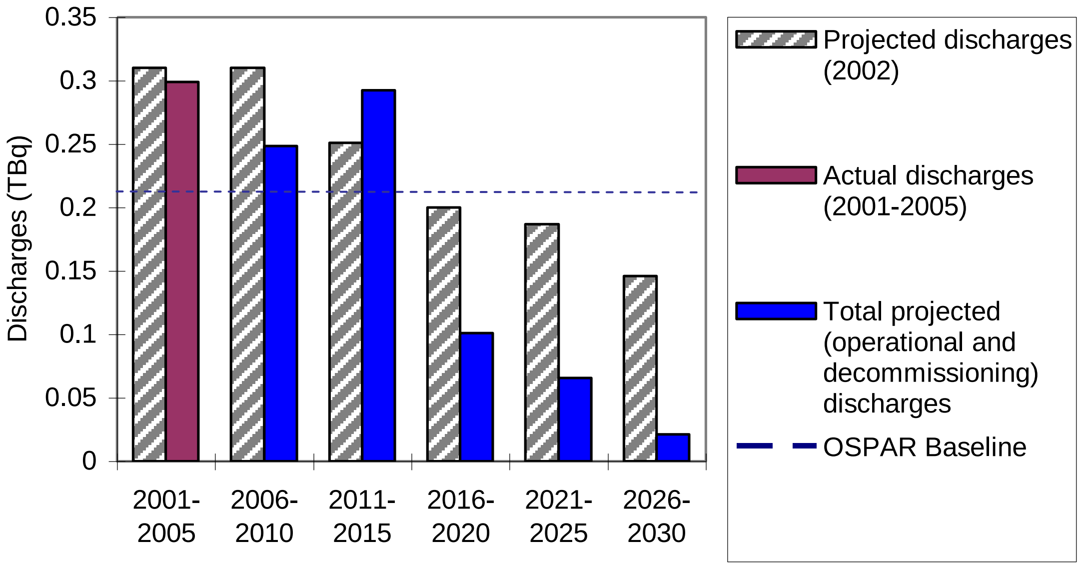


Target date	Target description	Target met?
2001 to 2005	Discharges	Actual in line with or less than projected.
2010	Closure of all Magnox power stations	Expected to be met.
2020	Total β/γ (except H-3) <1.5 TBq/yr	Expected to be met on current AGR lifetime assumptions.
2020	H-3 about 850 TBq/yr	Expected to be met on current AGR lifetime assumptions.

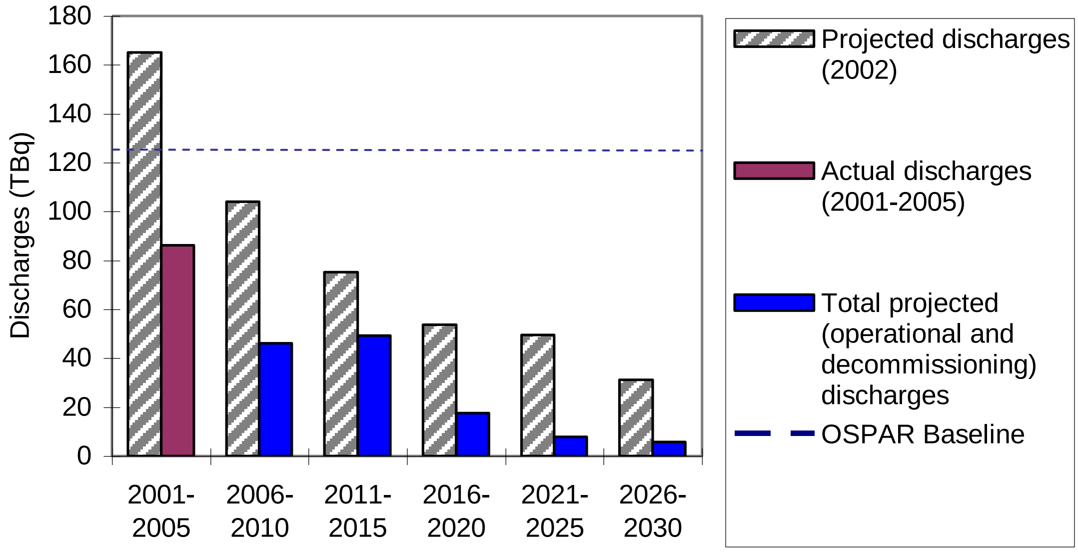
5.2.7 Spent fuel reprocessing sector

Figure 5.3 – Spent fuel reprocessing sector: evaluation of progress*

Total alpha

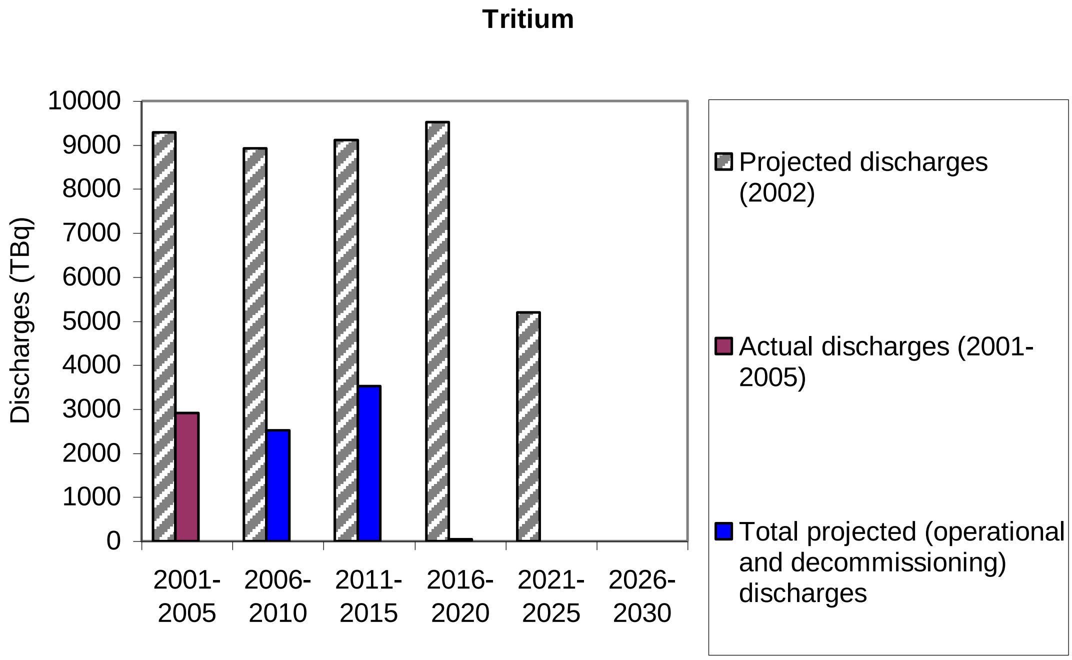


Total beta



*Projected discharges do not include effluents from the final phase of decommissioning activities. See section 9.4.

Figure 5.3 – Spent fuel reprocessing sector: evaluation of progress*

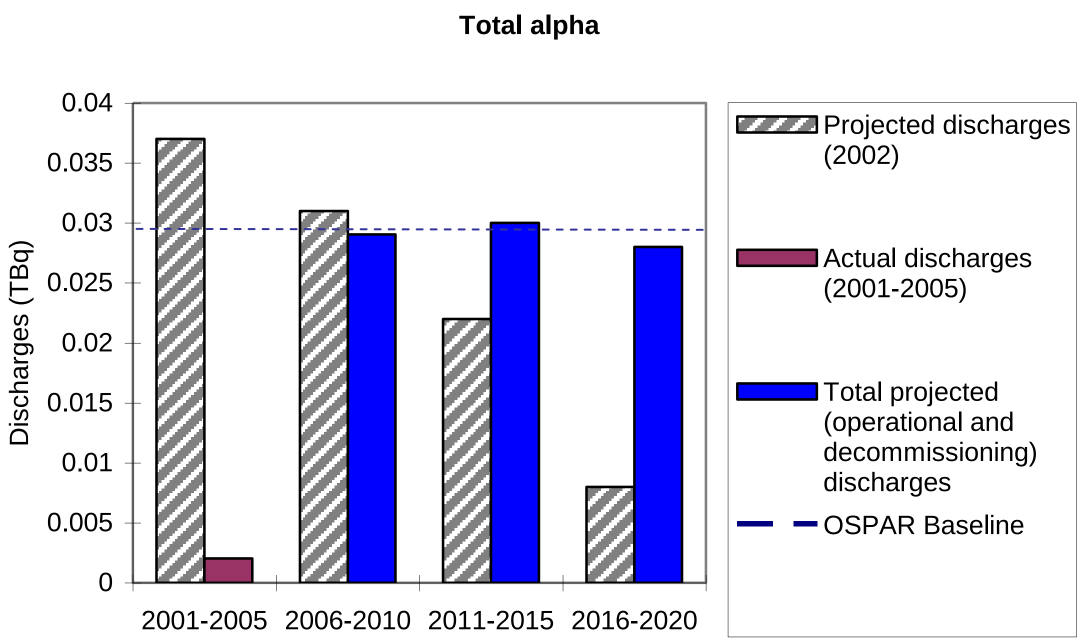


* Projected discharges do not include effluents from the final phase of decommissioning activities. See section 9.4.

Target date	Target description	Target met?
2001 to 2005	Discharges	Actual in line with projected (less than projected for total beta and tritium).
2006	Tc-99 (technetium-99) < 10 TBq/yr	Target met.
2020	Tc-99 < 1 TBq/yr	Target expected to be met.
2012	Magnox reprocessing ends around 2012	Target not expected to be met. Magnox reprocessing currently expected to be completed 2016 or later (see paragraph 5.2.11 and chapter 9).
2020	Total alpha/beta (except H-3) around 50 TBq/yr	Expected to be met, even with pessimistic scenarios.

5.2.8 **Nuclear research sector**

Figure 5.4 – Nuclear research sector: evaluation of progress



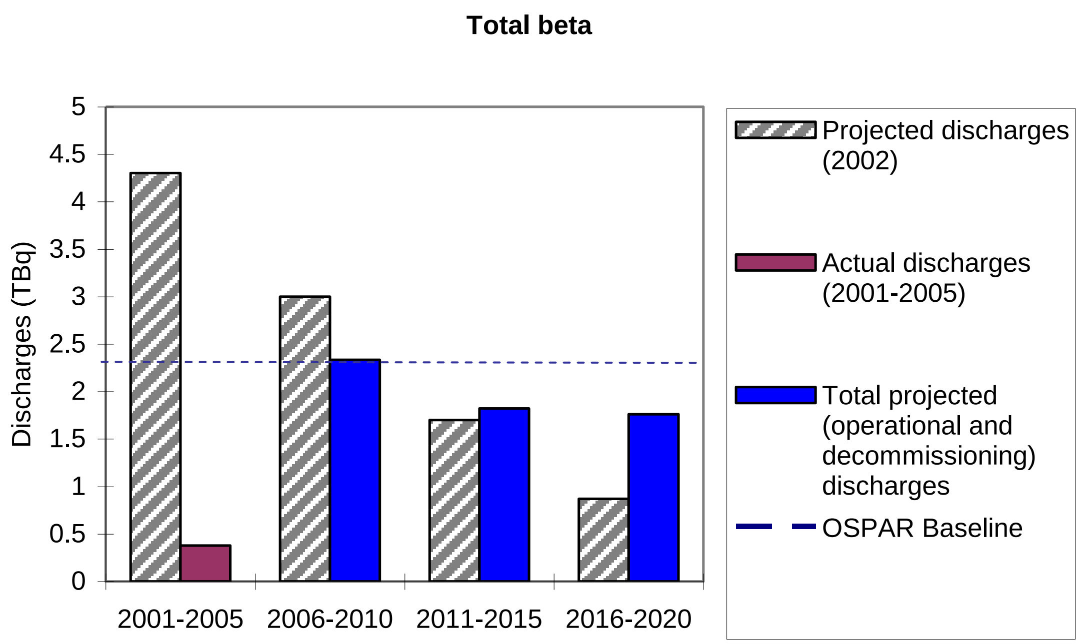
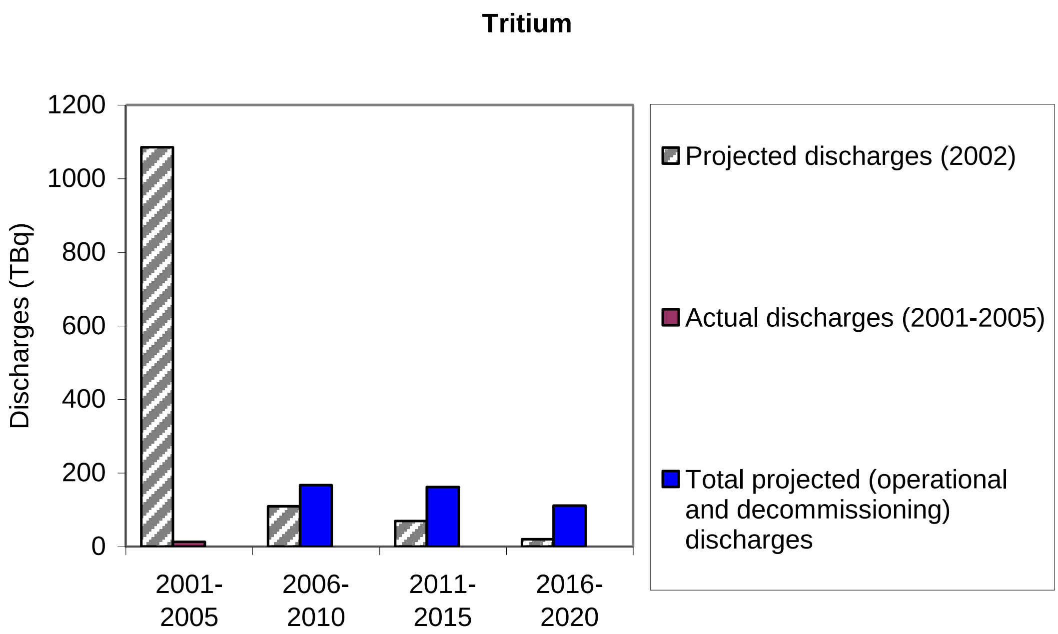


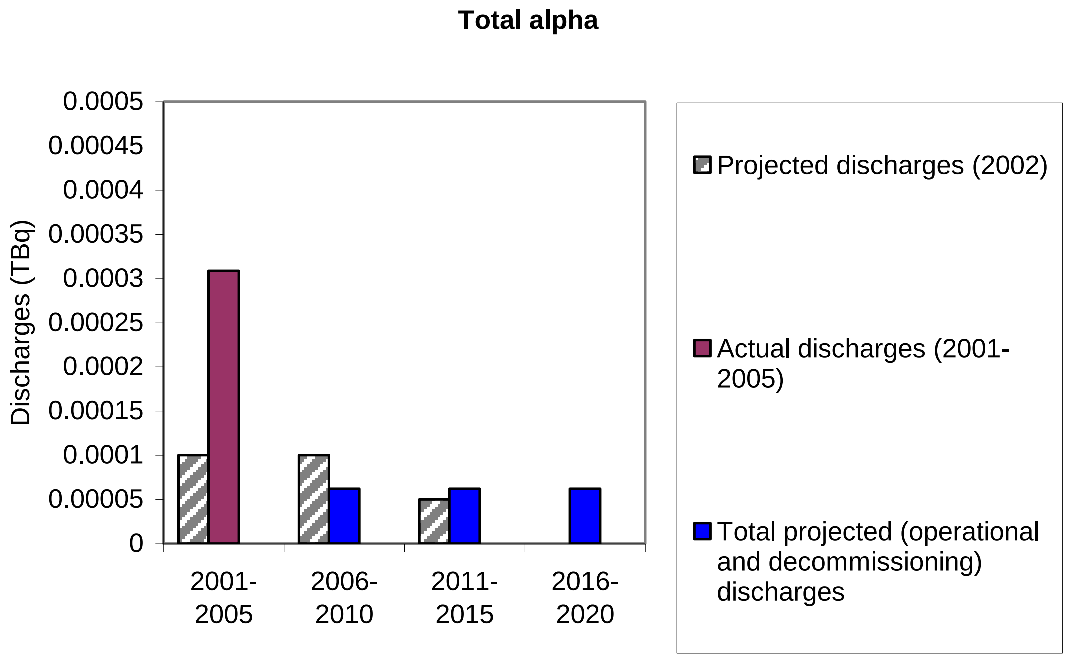
Figure 5.4 – Nuclear research sector: evaluation of progress



Target date	Target description	Target met?
2001 to 2005	Discharges	Actual discharges were significantly less than projected in the 2002 strategy. The projections were based on planned decommissioning activities which in practice progressed more slowly than planned, and contained a large margin of error due to the uncertainties in decommissioning discharges at that time.
2020	Total-α about 0.008 TBq/yr	On the basis of current lifetime plans, total-α expected to be <0.025 TBq/yr.
2020	Total-beta/yr (except H-3) about 0.9 TBq/yr	Expected to be met.
2020	H-3 about 20 TBq/yr	On current lifetime plans, H-3 discharges could average around 90 TBq/yr in the period 2016-2020.

5.2.9 **Defence sector**

Figure 5.5 – Defence sector: evaluation of progress



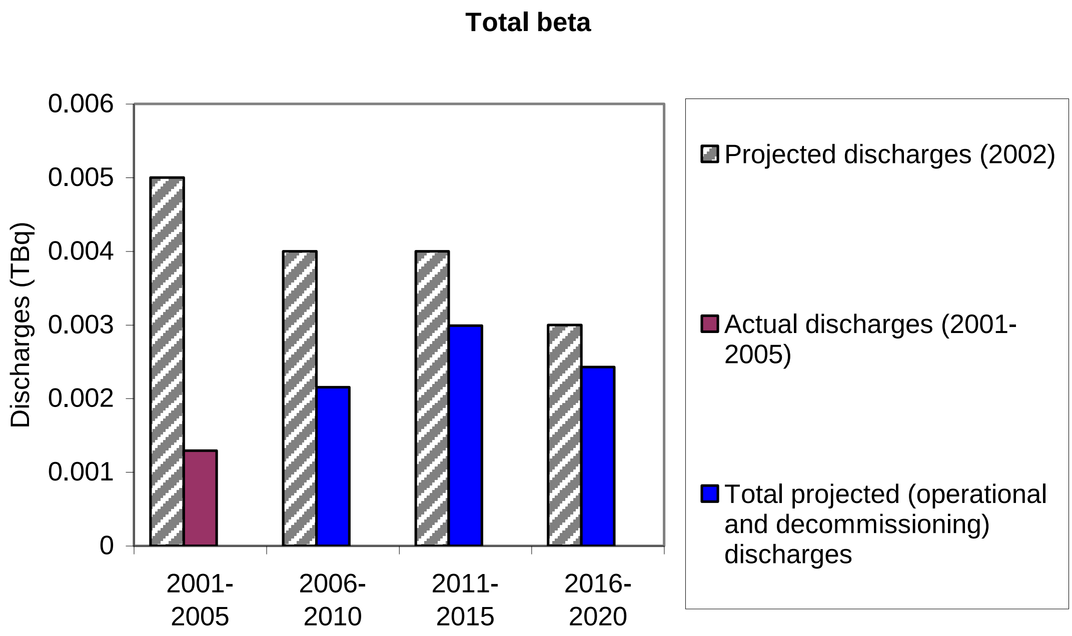
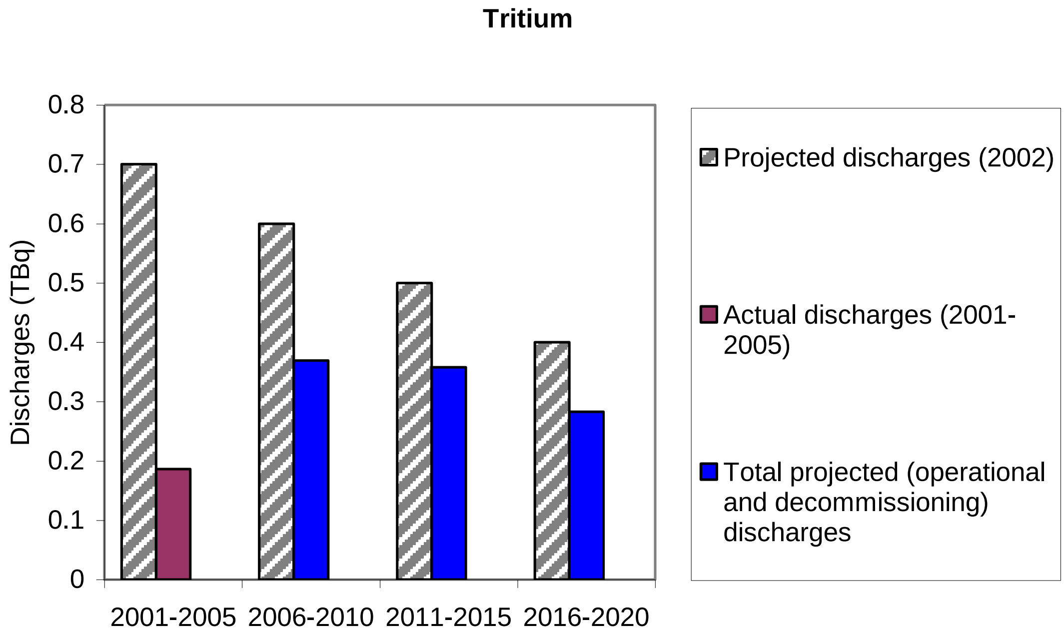


Figure 5.5 – Defence sector: evaluation of progress



Target date	Target description	Target met?
2001 to 2005	Discharges	Total beta and H-3 discharges were lower than projected. Total alpha actual discharges higher than projected as the 2002 projections did not include decommissioning discharges.
2002	End discharges to Thames from Aldermaston	Target met.
2020	Total beta/yr discharges (except H-3) down to 0.003 TBq/yr	Target already met.
2020	H-3 down to 0.4 TBq/yr	Target already met.

Discharge conclusions

5.2.10 **Discharge projections**: The 2002 Strategy contained fourteen sets of discharge projections, by sector and radionuclide (or radionuclide group). In all but one case, discharges between 2001 and 2005 were in line with projections. In general, it can be concluded that discharges are currently consistent with or are reducing faster than the projections in the 2002 Strategy. For those sectors where OSPAR has set baselines, average total-beta discharges for the period 2001 to 2005 were mostly below the baseline value, but were just above it for the fuel production and uranium enrichment sector. Total-alpha average discharges in 2001 to 2005 were below baseline values for the energy production and research sectors, but above them for the fuel production and reprocessing sectors.

5.2.11 **Targets:**

- Of the fifteen specific, sectoral targets in the 2002 Strategy, most have either already been met or are expected to be met by their due date.
- The target of ceasing Magnox fuel and UF_6 production is considered to have been met, since uranium ore concentrate processing ceased in 2006 and Magnox fuel production ceased in 2007 (see chapter 7) and this resulted in the anticipated significant reduction in discharges being achieved.
- The target of ending Magnox fuel reprocessing around 2012 is not expected to be met due to technical problems with the Magnox reprocessing plant and with evaporative capacity at Sellafield (see chapter 6). The completion of Magnox reprocessing is now likely to take place in 2016 or later. This does not affect the ability of the site to meet the target in the 2002 Strategy of reducing alpha/beta discharges to around 50 TBq per year by 2020 (see chapter 9). Nor will it mean that more radioactivity is discharged overall.
- Targets relating to discharge levels in 2020 remain valid and achievable in most cases. For total-alpha and total-beta discharges from the nuclear fuel production and uranium enrichment sector, and for total-alpha and H-3 discharges from the nuclear research sector, the targets in the revised strategy are higher, owing to updated assumptions regarding decommissioning timescales.

5.2.12 The first periodic evaluation of progress towards achieving the objectives of the OSPAR RSS was carried out in 2006, in relation to discharges[27]. This assessment compared baseline data with discharge data for 2002 to 2004 using a number of statistical tests. Although there was some evidence of reductions in discharges, the general conclusion was that given the short period covered by data it could not at that time be said whether the aims of the OSPAR RSS were being delivered.

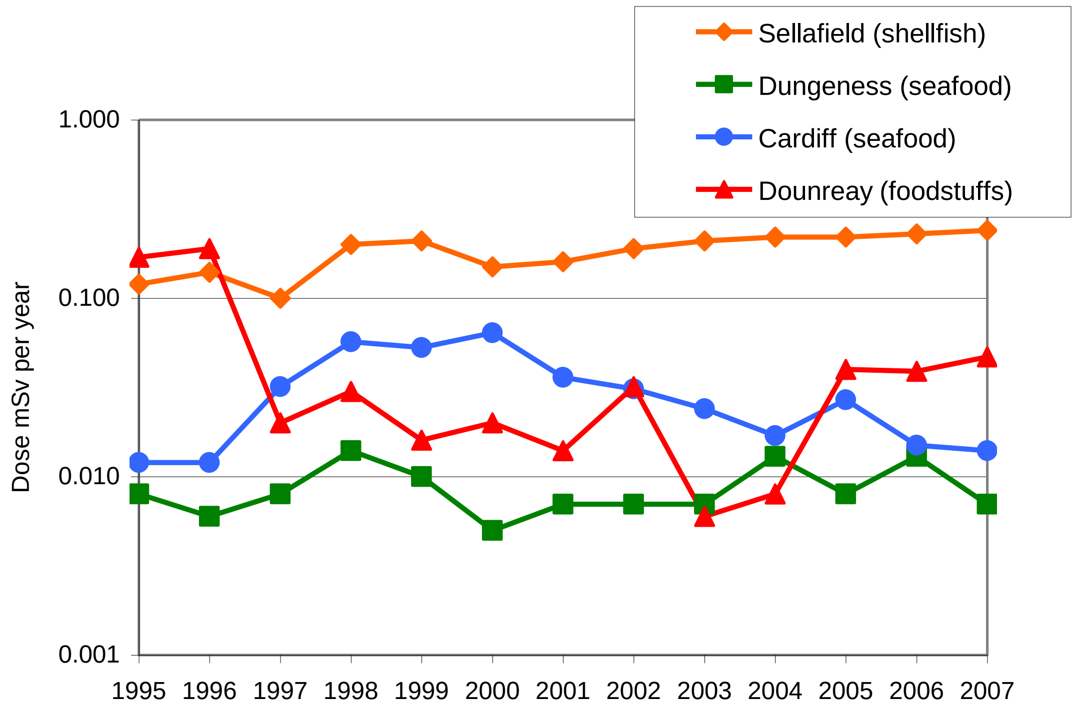
[27] Revised first periodic evaluation of progress towards the objective of the OSPAR Radioactive Substances Strategy. OSPAR Commission, 2006.

5.3 Doses - 1995 to 2007

5.3.1 Evaluation of trends in doses to the critical group has been carried out for the period 1995 to 2007 for the following sites which represent both different sectors and a spread of geographic locations: Dungeness (nuclear energy production), Sellafield (reprocessing), Dounreay (nuclear research) and Cardiff (isotope production). The following graph (Figure 5.6) compares the doses for consumers of seafood or terrestrial food for each of these sites.

5.3.2 It is important to note that assessed doses associated with radioactive discharges from various sources may vary from one year to another owing to changing assumptions about people's habits and food consumption patterns, as well as to changes in the concentrations of radioactivity in the environment.

Figure 5.6 –Trends in doses 1995-2007 (logarithmic scale)



Source: Radioactivity in Food and the Environment (RIFE) reports 1–13 produced by the Environment Agency (reports 8 - 13), Environment and Heritage Service Northern Ireland (8–12), Northern Ireland Environment Agency (13), Food Standards Agency (1 – 13) and Scottish Environment Protection Agency (2 – 13).
*For Sellafield, annual habit data is used up to 2000 inclusive; 2001 onwards uses data from five-year rolling average habit data.
**Cardiff data for 1995 and 1996 excludes contribution of dose from organically bound tritium.

5.3.3 **Dungeness:** There are two power stations located on the Dungeness site (chapter 8), one of which ceased operation in December 2006. The dose to the critical group of seafood consumers (local bait diggers) has remained low and fairly consistent over the past ten years, the variability is predominantly due to the normal variability expected in such low concentrations and dose rates in the environment. It is worth noting that these doses represent about one tenth of the maximum dose from the site in 2006 resulting from gaseous discharges (0.13 mSv), principally argon-41 (Ar-41).

5.3.4 **Sellafield:** Discharges from the Sellafield site (principally from the reprocessing of spent nuclear fuel) and resultant concentrations in the marine environment (see section 5.4.5) have been reducing over the time period of 1996 to 2006. The Sellafield dose to critical group is calculated for the local group of high-rate fish and shellfish consumers. The majority of this dose is due to historic discharges from the site. In 2006, the radionuclides giving the largest contribution to the food component of the dose (79%) were plutonium-239&240 (Pu-239&240) and americium-241 (Am-241). The slight increase in doses over recent years is mostly due to changes in consumption habits (particularly molluscs) and not from increases in concentrations of radionuclides in foods.

5.3.5 **Dounreay:** Since 1996, the radioactive discharges from the nuclear research site at Dounreay have been as a result of decommissioning activities (chapter 10). The main radionuclide contributors to dose to the critical group (local terrestrial foodstuff consumers) include strontium-90 (Sr-90), niobium-95 (Nb-95), caesium-137 (Cs-137), europium-155, uranium, plutonium and Am-241. In general the dose to the critical group has been decreased, although the last few years have seen a small increase in the dose to the critical group. This is largely due to the recent increased limit of detections (LoDs) for Am-241 and Iodine-129 in goats' milk and potato samples, respectively, the inclusion in the monitoring programme of radionuclides in goat's milk (2006), and also to the use of a relatively high laboratory limit of detection for concentrations of iodine-129 (I-129) in 2005.

5.3.6 **Cardiff:** A manufacturing facility operated by GE Healthcare in Cardiff (see chapter 12) produces radiolabelled compounds used in research. Liquid discharges of H-3, carbon-14 (C-14) and iodine -125 (I-125) are discharged to a local sewer which discharges into the Severn Estuary. The dose to the critical group (fish and shellfish consumers' prenatal children) has been generally reducing in recent years, which is consistent with continued reductions in liquid discharges and resultant reductions of tritium concentrations in the marine environment (Figure 5.9).

5.3.7 **Dose conclusion:** Critical group doses for these selected sites (and all other UK nuclear and non-nuclear sites) remain well below the EU and UK dose limit for members of the public from artificial sources of 1 mSv per year.

5.4 Concentrations in the marine environment 1995 to 2007

5.4.1 Concentration data, sourced from annual RIFE reports, for key marine environmental indicators, over the period 1995 to 2007, have been used to evaluate the 2002 Strategy.

5.4.2 Figures 5.7 to 5.15 provide environmental concentrations with time, at nine monitoring locations, for a number of indicators. It is not possible to include estimates of uncertainty and variability in the measurements shown in figures 5.7 to 5.15. However, the conclusions presented here are based on a detailed analysis of the data and take into account the measurement uncertainties and the natural variability between samples.

5.4.3 The locations, types of radionuclides analysed and the indicator materials were previously identified for the 2002 Strategy and closely correspond to monitoring carried out for OSPAR purposes. Monitoring locations are provided in Map 2. Owing to the large variation in levels, concentration data have been reported as logarithmic values to enable graphical representation.

5.4.4 Hollow symbols within the individual line graphs indicate data that have been measured and recorded as below the limit of detection (LoD). In circumstances where comparisons are made for time trends that include LoD values, the LoD may introduce a point bias (outlier) and does not reflect trends in the positive date time series. Commentary on figures 5.7 to 5.15 in paragraphs 5.4.5 and 5.4.6 is restricted, therefore, to positive value readings.

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Map 2 – OSPAR monitoring locations in the marine environment

Figure 5.7 –Concentrations, Scilly Isles 1995-2007

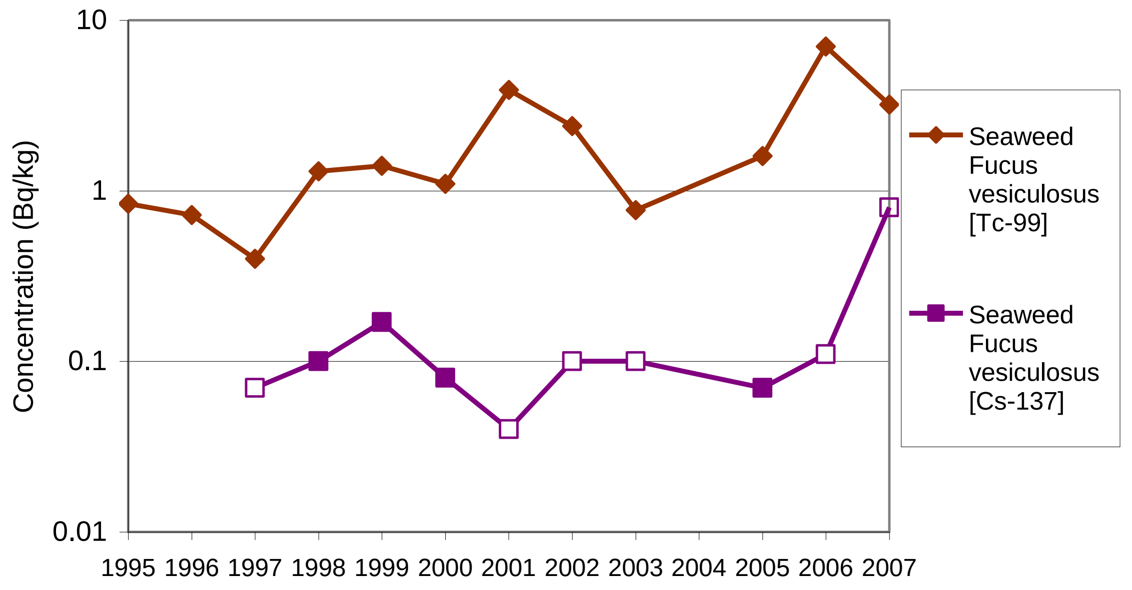


Figure 5.8 –Concentrations, Sellafield 1995-2007

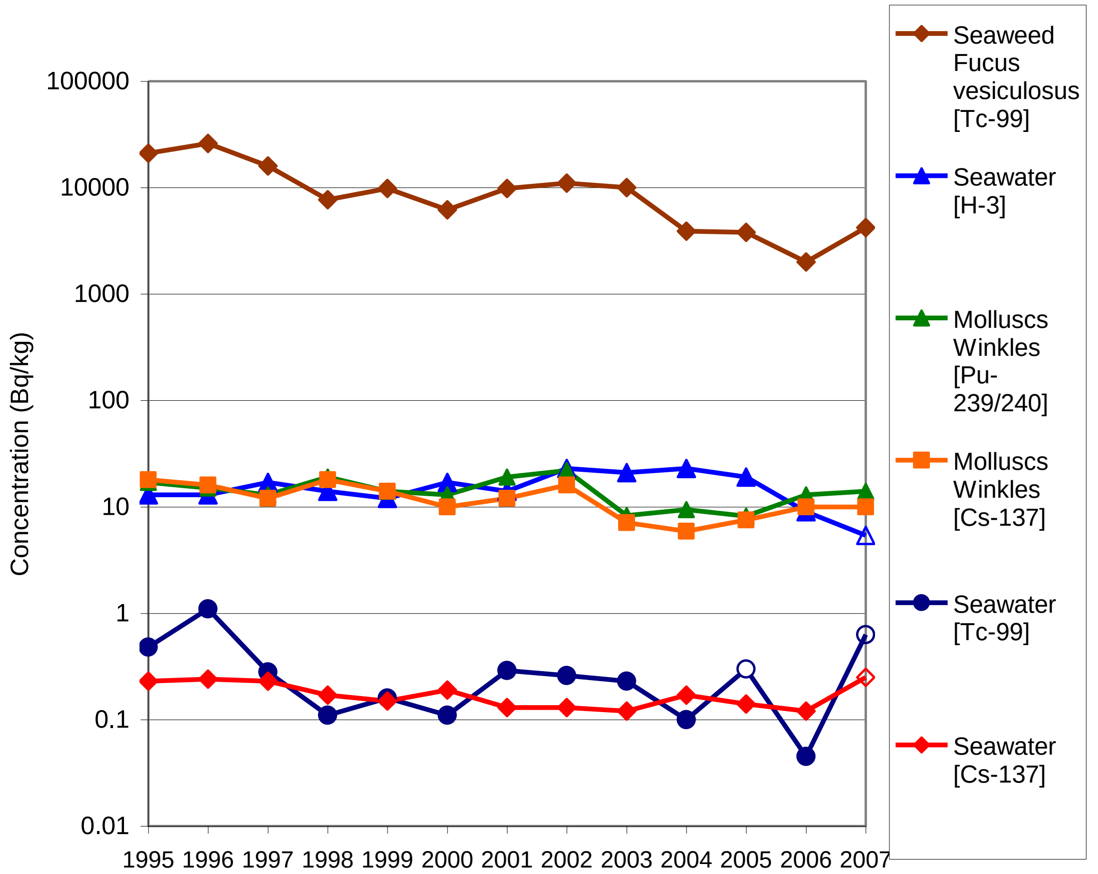


Figure 5.9 –Concentrations, Cardiff, Seven Estuary 1995-2007

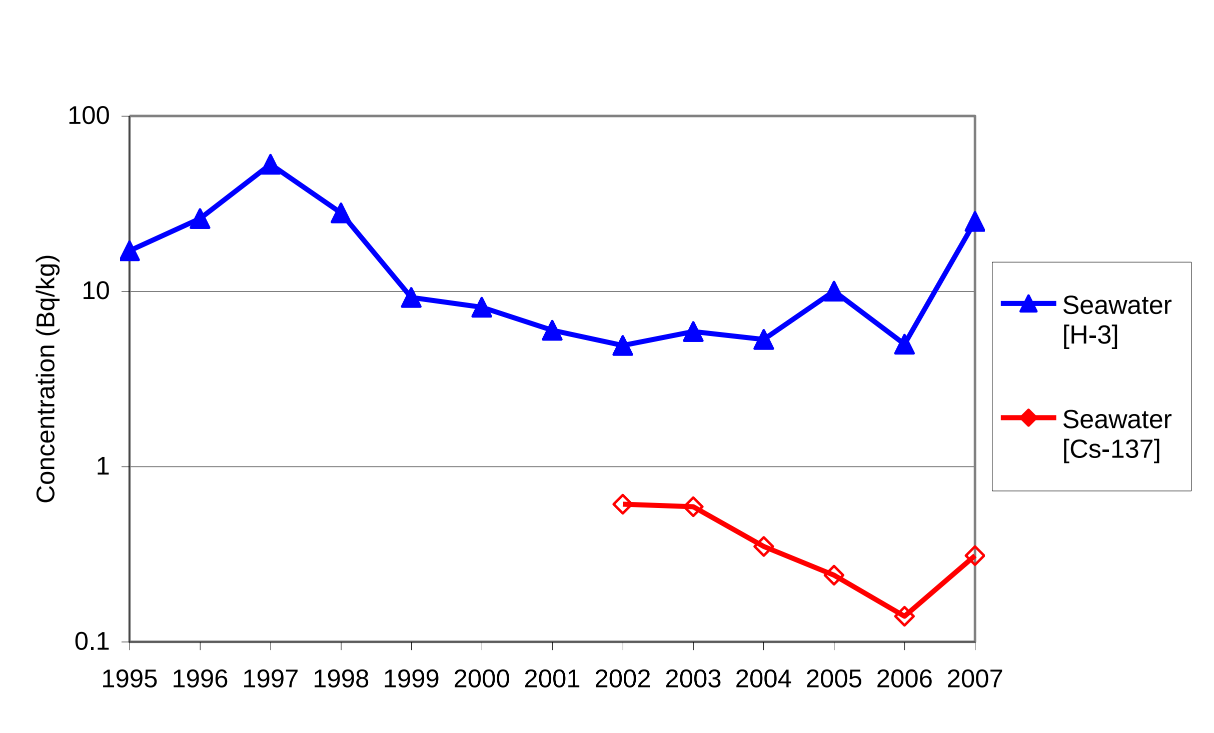


Figure 5.10 –Concentrations, Northern Ireland 1995-2007

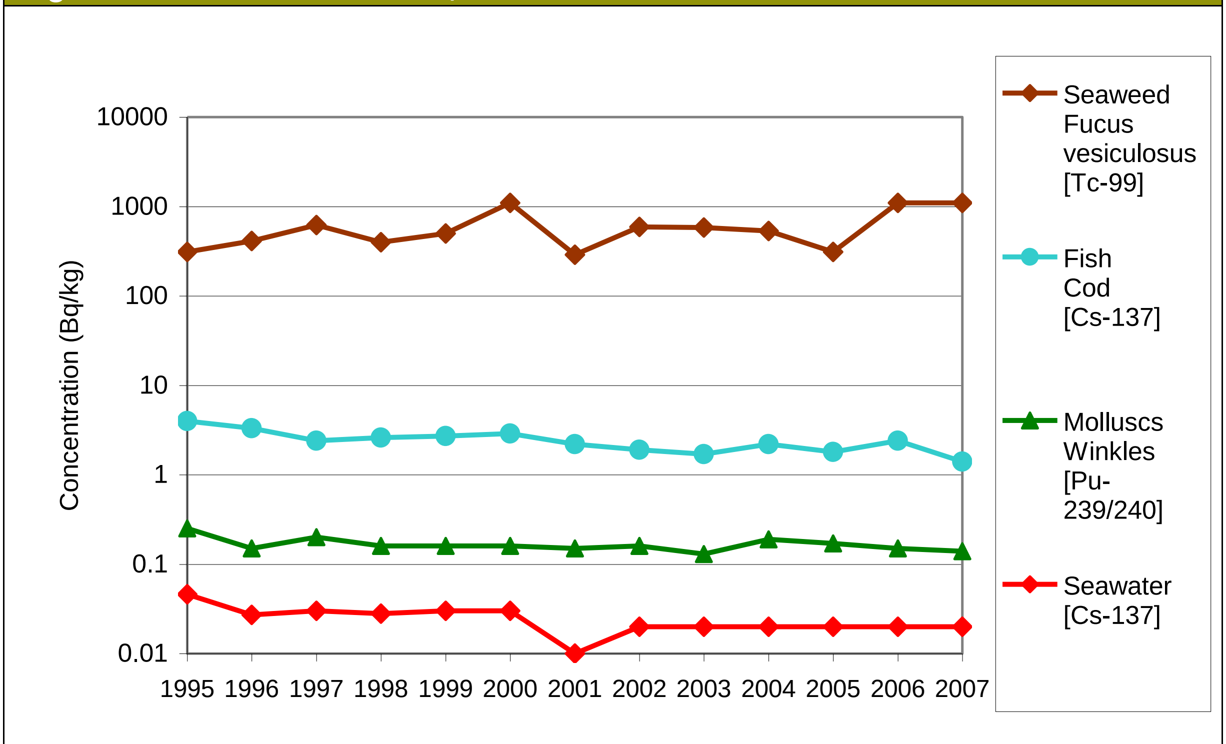


Figure 5.11 –Concentrations, Wylfa, Anglesey 1995-2007

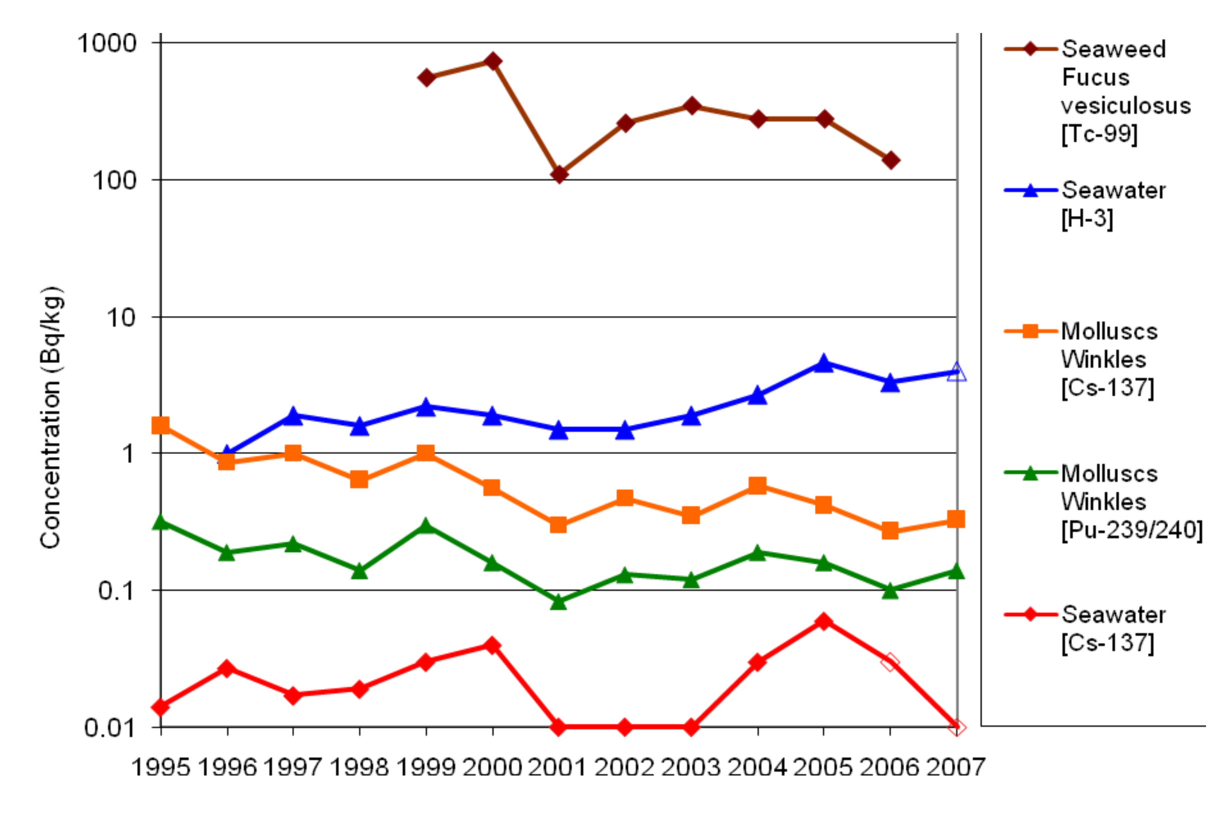


Figure 5.12 –Concentrations, Dounreay 1995-2007

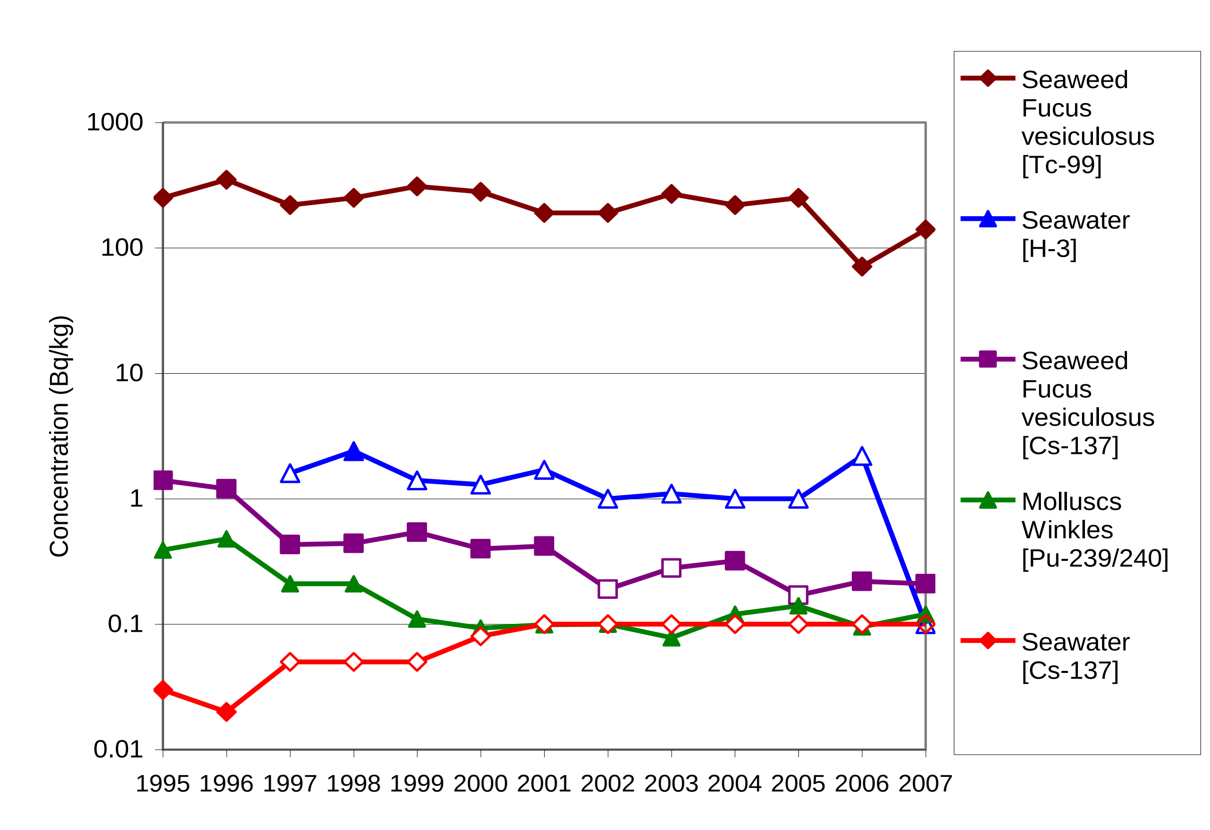


Figure 5.13 –Concentrations, Northern North Sea 1995-2007

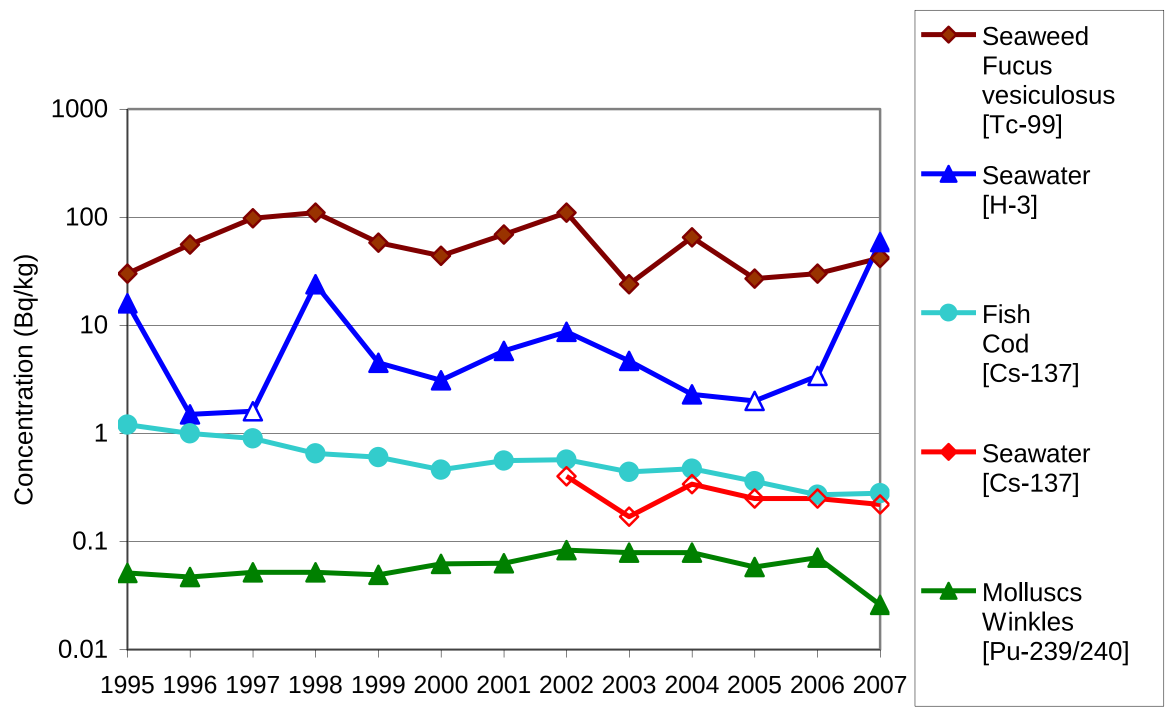


Figure 5.14 –Concentrations, Southern North Sea 1995-2007

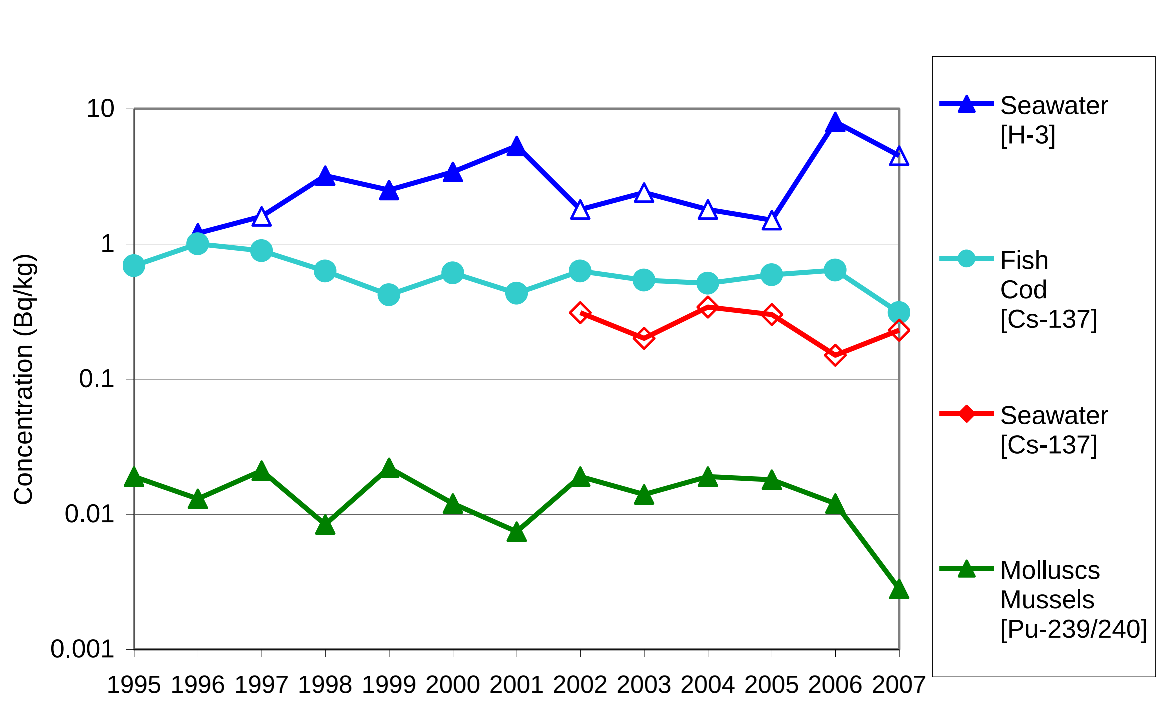
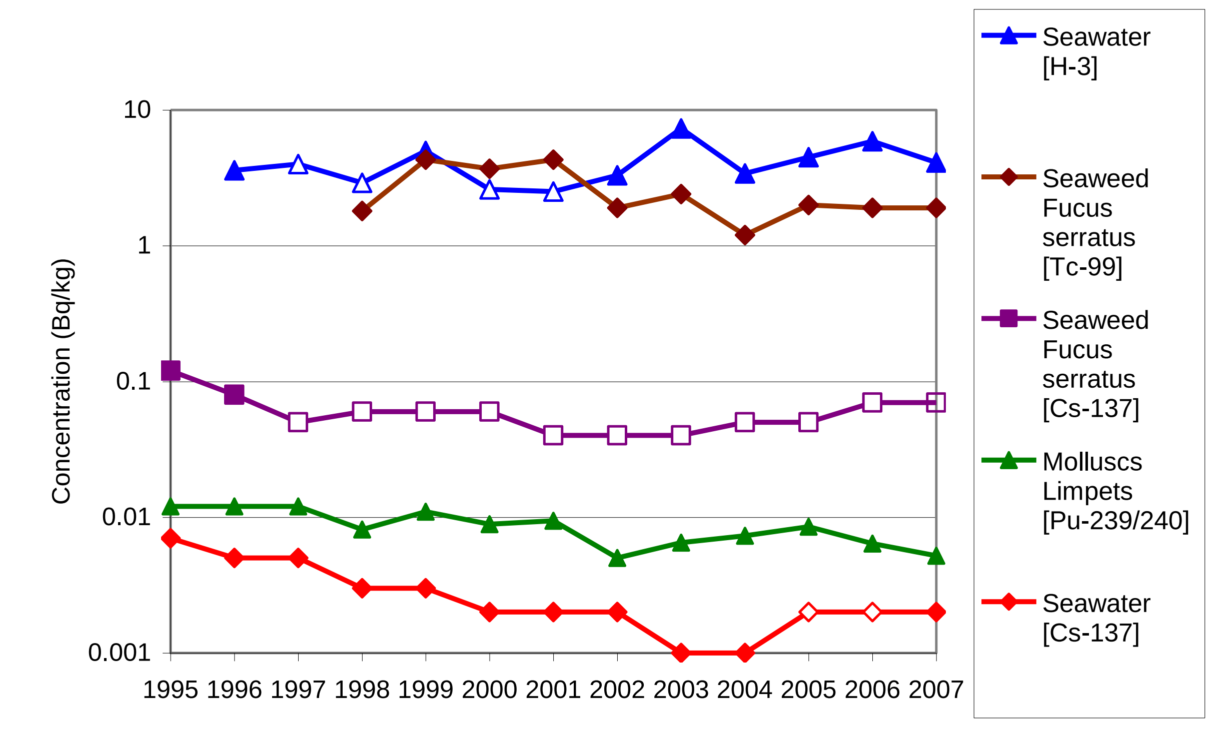


Figure 5.15 –Concentrations, Channel Islands 1995-2007



5.4.5 Overall, the highest concentrations in environmental indicator materials are found near Sellafield. There are indications of a decline over the time period in concentrations in environmental indicator materials at the majority of the monitoring locations. Data for the Scilly Isles (Figure 5.7), could be considered to represent a "background" situation, that is largely unaffected by recent UK discharges. Observed fluctuations at this location are most likely from the redistribution of historic discharges (and other sources) due to environmental processes.

5.4.6 **Sellafield:** At Sellafield (Figure 5.8), concentrations of radionuclides in environmental indicator materials have decreased over the period of monitoring. Whilst concentrations of Cs-137 in seawater have declined by approximately a factor of two (from 0.23Bq/kg to 0.12Bq/kg), Tc-99 levels in seawater (and seaweed) up to 2006 declined by approximately 10 fold (from 0.48Bq/kg to 0.045Bq/kg and from 21000Bq/kg to 2000Bq/kg, respectively). Reductions in Tc-99 concentrations appear to result directly from the most recent decreases in discharges since 1995. Cs-137 levels in molluscs have also decreased by a nearly a factor of two (from 18Bq/kg to 10Bq/kg) whilst, in comparison, Pu-239+240 levels in molluscs have shown a tendency to decline at a slower rate. These observations result from the relative chemical reactivity of particles containing Cs-137 and Pu-239+240 and the impact of remobilisation of sediment-bound radionuclides from historic discharges.

5.4.7 **Cardiff, Northern Ireland, Wylfa and Dounreay:** Levels of concentrations in environmental indicator materials at Cardiff (Figure 5.9), Northern Ireland (Figure 5.10), Wylfa (Figure 5.11) and Dounreay (Figure 5.12) represent the impact of Sellafield as a function of distance from this major source. Concentrations of Cs-137 in seawater have clearly declined with time for Northern Ireland, whilst levels have remained reasonably constant for the other locations, probably due to remobilisation of Cs-137 from the muddy sediments of the Irish Sea. Discharges of Tc-99 from Sellafield have resulted in variations in concentrations at Northern Ireland and Dounreay (with delays concomitant with water transport), but the overall pattern is for concentrations to decrease with time. Tc-99 levels in fucus vesiculosus declined from 1999 to 2006(from 560Bq/kg to 500Bq/kg) to the south of Sellafield (at Wylfa). No data was available for 2007. Pu-239+240 levels in molluscs have declined at these locations, with the largest decline (from 0.39Bq/kg to 0.12Bq/kg) being at Dounreay. Again, these observations are likely to result from remobilisation of sediment-bound Pu-239+240 from historic discharges.

5.4.8 **Northern North Sea, Southern North Sea and Channel Islands:** The concentrations levels in environmental indicator materials for the Northern North Sea (Figure 5.13), Southern North Sea (Figure 5.14), and the Channel Islands (Figure 5.15) represent the least impact from Sellafield and therefore variations in concentrations are more likely to be due to variations in water transport and environmental processes. Most recent concentrations of Cs-137 in seawater are at, or below, the limit of detection. Concentrations of Cs-137 in fish are generally decreasing, although this is less apparent for the Southern North Sea in comparison to the Northern North Sea. Pu-239+240 levels in molluscs have declined at the Channel Islands due to the reducing impact of Sellafield (and the La Hague reprocessing plant in northern France) discharges and the water transport patterns. Levels have remained reasonably constant for the other two locations, probably due to remobilisation/transport of sediment-bound Pu-239+240 from historic discharges. Slightly elevated Tritium activity in the Northern North Sea appears to have been due to water sampling being conducted following a discharge to sea.

5.4.9 **OSPAR maritime area:** The second periodic evaluation of progress towards achieving the objectives of the OSPAR RSS was carried out in 2007 and looked at concentrations of key radionuclides and radionuclide groups in seawater and marine biota. This assessment compared baseline data for the mean of recorded concentrations for the period 1995 to 2001, with concentration data for 2002 to 2005 using a number of statistical tests. There was some evidence of reductions in concentrations, although there were also some cases where no change in concentrations could be determined and in a minority of cases there appeared to be increases. In the same way as the first periodic evaluation report on discharges, the general conclusion was that, given the short post-baseline period covered by the available data, it could not at that time be said whether the aims of the OSPAR RSS were being delivered.

5.4.10 **Concentrations conclusions:** Overall, the decline in concentrations of environmental indicator materials appears to be greatest in locations close to

Sellafield (Irish Sea)[28]. This is predominately likely to be due to reductions in discharges. Further afield, the impact from the historic legacy of discharges is more apparent in the resultant concentrations in environmental indicators. This is likely to continue, especially for particle-bound radionuclides such as Pu-239&240.

5.4.11 There is a need to regularly review the capability of marine dispersion models. There is evidence to suggest that these predictive models may need to be developed further to consider release of colloidal and particulate radioactivity.

5.5 Overall conclusions

5.5.1 Whilst acknowledging the importance of historic discharges, evidence from data on reported discharges and environmental concentrations and from dose estimates based on these data, that the aims of the 2002 Strategy for radioactive discharges are broadly being met or are likely to be met by 2020. In addition, most of the fifteen specific, sectoral targets included in the 2002 Strategy have already been met or are expected to be met by their due date.

5.5.2 It is disappointing that the current Magnox Operating Programme (MOP) shows that target of ending Magnox spent fuel reprocessing at Sellafield by around 2012 currently appears unlikely to be met, owing to the technical difficulties described below. However, the expected delay in achieving this target will not affect overall discharges or compromise the expected reductions in discharges from the site by 2020.

5.5.3 Eleven Magnox power stations were built in the UK, with a total of 26 Magnox reactors. All but four of these reactors are now shut down and 10 reactors have been completely defuelled. To defuel, spent fuel must be removed from the reactors and stored in the sites' ponds or dry stores before being shipped to Sellafield in flasks, where it is reprocessed. The logistics of moving significant quantities of spent fuel from diverse sites using a limited number of flasks, road transporters and rail flatrols are complex as is balancing defueling rates at power stations with storage and reprocessing capacity at Sellafield. It is for these reasons that the MOP has been developed. The MOP is an integrated programme covering all business areas associated with the cost-effective management and safe disposal of spent Magnox fuel. This is available from the NDA website at www.nda.gov.uk.

5.5.4 Reprocessing capability is currently the key constraint on MOP delivery. Following the introduction of the MOP, in June 2001 there were significant improvements in reprocessing performance and the achievement of the target of ending Magnox spent fuel reprocessing at Sellafield by around 2012 was therefore considered achievable. However, following an extended outage at Sellafield in 2005, there have been a series of issues adversely affecting the performance of the Magnox Reprocessing plant (MRP) and the associated plants on which it depends. Also at the start of the MOP, the Fuel Handling Plant (FHP) pond at Sellafield contained around 600 tonnes of "legacy fuel" which is more difficult to process. By April 2006 260 tonnes of this legacy fuel

[28] RIFE12. Figures 2.7 to 2.12.

had been successfully reprocessed, but the remaining fuel has proved even more difficult to process than was initially anticipated. As part of the process to create the programme for the 8th revision of the MOP in 2008, detailed modelling and assessments have been performed to establish greater confidence in the reprocessing programme based on improved underpinning of expected plant performance. This concluded that the completion of the Magnox reprocessing programme is likely to take place in 2016 or later rather than around 2012 as was originally expected. This continued to be the case when the MOP was updated in January 2009.

5.5.5 The NDA is currently exploring contingency plans for alternative management options for Magnox spent fuel. These contingencies serve to minimise the risks associated with the current end date for the MOP while recognising that reprocessing is currently the only proven technically viable route for managing wetted Magnox fuel stocks.

5.5.6 Radioactive discharges in general are currently in line with, or are reducing faster than, the projections given in the 2002 Strategy. As a result, measured concentrations in the marine environment have also declined, most noticeably at those locations closest to Sellafield. In addition, estimated doses to members of the public have also declined in real terms (although this is not always obvious owing to changes in assumptions about eating habits) and remain a small fraction of the UK and EU dose limit for members of the public from artificial sources of 1 mSv per year.

Chapter 6 - Uncertainties and next steps

6.1 Uncertainties that could affect the achievement of strategy outcomes

6.1.1 The discharge projections provided in this strategy and the expected outcomes accompanying them represent best estimates of the discharge reductions that appear to be achievable on the basis of current assumptions. However, there will always be a degree of uncertainty attached to the projections and such uncertainties could be particularly significant for the nuclear energy production and reprocessing sectors.

6.1.2 The prospects of potential new nuclear build and, in the interim, the possible life extension of at least some of the existing power reactors could mean that the assumptions on which discharge projections for the nuclear energy sector are based will change during the lifetime of this Strategy. Uncertainties at the Sellafield site associated with THORP and the MRP mean that the assumed closure dates for these plants, and the resulting significant reduction in discharges from the site, may need to be reassessed in the light of developments.

6.1.3 Providing accurate predictions of decommissioning discharges is also challenging. The often very different nature of decommissioning activities, compared with normal site operations, also makes prospective discharges difficult to quantify. Estimates are therefore conservative and actual discharges may well be lower.

6.1.4 Non-routine decommissioning activities may be affected by changes to their planned timing, with consequent variation to the expected discharge profile. The NDA's Business Plan for 2008-2011 indicates that, in order to deliver real progress in dealing with higher hazard facilities, principally at Sellafield and Dounreay, NDA funding may need to be reprioritised from other areas. As a result, decommissioning programmes on lower hazard sites are likely to be slowed.

6.2 New nuclear build

Government policy on new nuclear power stations

6.2.1 Following a public consultation in 2007, the Government, published ‘Meeting the Energy Challenge: A White Paper on Nuclear Power’ in January 2008 (“the White Paper”). In the White Paper, the UK Government concluded that “new nuclear power stations should have a role to play in this country’s future energy mix alongside other low-carbon sources; that it would be in the public interest to allow energy companies the option of investing in new nuclear power stations; and that the Government should take active steps to facilitate this”. The Scottish Government did not endorse the White Paper and will be pursuing other renewable power options.

6.2.2 The nuclear consultation and White Paper addressed a number of areas that are also relevant to this strategy. In particular, they considered the environmental impacts that arise at different stages of the nuclear life cycle. The White Paper set out the Government's belief that "the environmental impacts of new nuclear power stations are manageable, given the requirements in place in the UK and Europe to assess and mitigate the impacts"[29].

6.2.3 The White Paper also confirmed that the Government would undertake a Strategic Siting Assessment (SSA) and Strategic Environmental Assessment (SEA). The aim of SSA is to establish at a strategic level which sites would be suitable or potentially suitable for the deployment of new nuclear power stations. The Government consulted on the SSA criteria and process in July 2008, and published its response in January 2009. The response explained that Government would run the SSA to identify and assess sites which have the potential to be suitable for the deployment of new nuclear power stations by the end of 2025. The outcome of the SSA process will form part of the draft National Policy Statement for nuclear power, which will be published for consultation in the Autumn of 2009.

6.2.4 The UK 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 the plans for, and financing of, waste management should proceed on this basis. The White Paper also stated that the UK Government are not currently expecting proposals to reprocess spent fuel from new nuclear power stations. Should such proposals come forward in the future, they would need to be considered on their merits at the time and the UK Government would expect to consult on them. The UK's current reprocessing facilities at Sellafield (the MRP and THORP) are expected to complete their existing contracts – see Chapter 9 of this consultation document for more information about the expected timetables for these plants and the projected discharges from them in the remaining years of their lives.

Potential impacts of new nuclear build on the UK Strategy for radioactive discharges and the management of solid waste

6.2.5 The Environment Agency is responsible for ensuring that new nuclear power stations can meet high environmental standards and that they will use BAT to achieve this, as required by the OSPAR RSS. The regulators for England and Wales (HSE and the Environment Agency) are currently carrying out Generic Design Assessment of proposals for new nuclear power stations[30]. Through this assessment, the Environment Agency is working to ensure that the need to meet high environmental standards is considered at an early stage and that the most modern techniques to minimise radioactive waste – including discharges to the environment – can be incorporated into the designs of modern nuclear power stations. The application of BAT in England and Wales will ensure that discharges from new nuclear power stations constructed in

[29] Nuclear White Paper Environment Section
[30] Section 3 of 'Meeting the Energy Challenge: A White Paper on Nuclear Power' January 2008

the UK will not exceed those from comparable power stations across the world**.**

6.2.6 Based on what energy companies have said, it is possible a programme of new nuclear build could exceed current generating capacity during the timeframe covered by this Strategy. On the basis of the low levels of discharges from current LLWRs in the UK and abroad, such a programme, on a purely illustrative basis, would not prevent the UK from achieving the objective of the OSPAR RSS.

6.2.7 In its White Paper on Nuclear Power, the UK Government set out its conclusion that:

> "Having reviewed the arguments and evidence put forward, the Government believes that it is technically possible to dispose of new higher-activity radioactive waste in a geological disposal facility and that this would be a viable solution and the right approach for managing waste from any new nuclear power stations. The Government considers that it would be technically possible and desirable to dispose of both new and legacy waste in the same geological disposal facilities and that this should be explored through the Managing Radioactive Waste Safely programme. The Government considers that waste can and should be stored in safe and secure interim storage facilities until a geological facility becomes available. Our policy is 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 also believes that the balance of ethical considerations does not rule out the option of new nuclear power stations."

A further White Paper, Managing Radioactive Waste Safely: A Framework for Implementing Geological Disposal, was published in June 2008[31].

6.3 Possible life extension of AGR power stations

6.3.1 AGRs are currently producing electricity at seven of the ten operating nuclear power stations in the UK. The discharge projections set out in the strategy are based on the current assumed closure dates for these reactors which range from 2014 to 2023 (following deferment of the closure of Hunterston "B" and Hinkley Point "B" from 2011 to 2016). However, to ensure the security of energy supply during the period before any proposed new nuclear power plants become operational, it is possible that British Energy (BE) may wish to apply for further extensions to the lifetimes of at least some of the current AGR stations. Before granting any such extensions, the regulators will need to

[31] Managing Radioactive Waste Safely: A Framework for implementing geological disposal. Defra 2008. Available at http://defraweb/environment/radioactivity/mrws/index.htm

be satisfied that operations at these sites can continue to meet all relevant safety and environmental requirements.

6.3.2 As the number of AGR stations for which life extensions may be granted, and the length of such extensions are unknown, it is not possible to predict with accuracy the effects of possible AGR life extensions though the extensions would obviously increase the potential that the projections will not be achieved. The projections will need to be revised once some of the uncertainties are removed (i.e. the next revision of the Strategy). However, as an indication, current data indicate the following additional average discharges for the nuclear energy production sector, per station per year (TBq/yr), above those projected at chapter 8.

	Average additional discharges per station per year
Total alpha	0.00003 TBq
Total beta	0.6 TBq
Tritium	339TBq

High Level Waste Plants Evaporative Capacity

6.3.3 There are three evaporator plants at Sellafield (with another being constructed), which are used to evaporate highly active residues from THORP, Magnox reprocessing and the vitrification of highly active liquid wastes. This evaporation is necessary to reduce the volumes of high active wastes. All three evaporators can handle wastes from Magnox reprocessing and vitrification, but only one can also be used for THORP residues. Technical problems have led to all three of these evaporators being taken out of service recently, for varying periods of time. The operator is working to develop robust predictions for the remaining operational lifetimes of the current evaporators, to ensure continued safe operations and to support reprocessing in both the Magnox plant and THORP. However, for safety reasons, residues arising from Magnox reprocessing and from waste vitrification are given higher priority than those from THORP operations. Whilst these uncertainties about evaporator capacity remain, the closure dates of THORP and the MRP cannot be predicted with confidence.

Closure dates for Magnox and THORP reprocessing

THORP

6.3.4 The NDA's intention is that all current overseas and UKAEA contracted fuel will be reprocessed through THORP and sufficient additional fuel will be reprocessed such that the remainder can be safely stored. The option of new business has not yet been foreclosed by the NDA, but any proposals for new contracts will require the approval of the UK Government. As set out in the White Paper "Managing the Nuclear Legacy"[32], in the event of such a proposal, the UK Government would look in detail not just at the

[31] Section 5.19 of 'Managing the Nuclear Legacy. A strategy for action' Cm 5552, July 2002

circumstances of the specific case, but would also review the range of issues which would be involved in increasing the current volume of fuel to be reprocessed through THORP. Approval would only be given if the proposal was consistent with clean-up plans for Sellafield, was expected to generate a positive return to the taxpayer and was consistent with the UK's environmental objectives and international obligations. In addition to the requirements set out in the White Paper "Managing the Nuclear Legacy", before making any decisions on any such proposal the Government would consult publicly.

6.3.5 Future technical reviews will be carried out to assess the potential for alternative uses for the THORP building and facilities, but on current assumptions the THORP reprocessing facility is envisaged to be required until 2015, with operations to be followed by a phase of Post Operational Clean Out (POCO) and then decommissioning. Following POCO of the main THORP plant areas, in addition to those parts of the plant required for safety, e.g. ventilation systems, parts of the THORP plant will be required to remain operational to support other activities on the site.

Magnox Reprocessing

6.3.6 As described in 5.5.2 the MOP is an integrated programme covering all business areas associated with the cost-effective management and safe disposal of spent Magnox fuel and, as such, supports the NDA strategy of managed reduction of potential hazards. There are several uncertainties and risks associated with the Magnox reprocessing work programme and associated plans for Magnox stations, which are summarised within the MOP. The latest version of the MOP is available on the NDA's website (www.nda.gov.uk).

6.3.7 Risks, uncertainties, contingency measures and opportunities associated with the MOP are reviewed periodically. At Sellafield, a large number of downstream plants and site services (such as the evaporators mentioned above) can potentially affect Magnox reprocessing operations. The NDA contractors charged with delivering and managing the MOP have adopted a prudent forecast of future reprocessing performance, which currently predicts that Magnox fuel reprocessing will be complete around January 2016.

6.4 Next steps

6.4.1 This Strategy sets out an updated statement of Government policy with regard to radioactive discharges, to inform decision making by industry and regulators and a strategic framework for the UK's implementation of the OSPAR RSS. It is underpinned by the internationally accepted principles of radiation protection and by a broad platform of environmental principles, many of which are also applied in fields outside that of radioactive substances. The Government believes that the application of these principles through the regulatory framework will continue to drive the delivery of progressive reductions in discharges, where practicable, in order to meet both the expected outcomes set out in this Strategy and the OSPAR intermediate objective for 2020.

6.4.2 In England and Wales, the application of BAT by the Environment Agency, in place of the current techniques of BPM and BPEO, will be of particular importance. Statutory Guidance to the Environment Agency will require them to set discharge limits based on the use of BAT and at the minimum necessary levels to permit normal operation or decommissioning of a facility.

6.4.3 A nuclear sector inter-industry group, the Environment Agencies Requirements Working Group, has developed a live database of national and international waste minimisation techniques. This best practice reference is expected to be of assistance to operators in determining suitable options for BAT or BPM/BPEO studies. The database is available at www.rwbestpractice.co.uk.

6.4.4 Discharges are monitored on an on-going basis and are reported annually to OSPAR. As mentioned in chapter 1, OSPAR carries out periodic evaluations of progress in achieving its RSS and these will feed into a Quality Status Review of the marine environment in the OSPAR area, to be published in 2010. We may also need to take into account any changes or additions to the OSPAR Strategy agreed at the next OSPAR Ministerial Meeting in 2010.

6.4.5 We intend to carry out a further review of the UK radioactive discharges strategy and to issue an updated version in 2014. By then, we expect many of the uncertainties described here to have been resolved (although others may have replaced them).

Part 2: Sources of radioactive discharges & future projections

Introduction

1. Chapters 7 to 14 each contain details of a sector that contributes to total radioactive discharges. Each chapter starts with an overview of the activities of the sector. This is followed by a standard template based on information provided by the site operators which includes a detailed analysis of the liquid and aerial discharges that are occurring:

    - The main source of discharges
    - The main types of radionuclides being discharged
    - Abatement technologies currently being used by operators and proposals/plans for future abatement technologies

Detailed explanation of standard template

2. **The main source of discharges** - This box describes from where in the process the majority of discharges originate.

   The main types of radionuclides being discharged – This box lists the main radionuclides being discharged by the site. These are as reported under RSA93 authorisations.

   Abatement technologies - The abatement technologies described are those that are being used now or that are planned to be used by operators to reduce emissions. These technologies are likely to change over time and the environment agencies will expect the operators to use BAT, or BPM in Scotland and Northern Ireland. It is the operators' responsibility to determine how and when they adopt new abatement techniques.

3. The doses to critical groups, discharge projections and expected Strategy outcomes until 2030 are detailed along with comments on any additional activities that are being planned on the site up to 2030.

4. Each graph in part 2 has been prepared to give a clear visual representation of what is projected to happen to a particular type of discharge for that sector. It is unavoidable that there are a number of different scales for the graphs, reflecting the different levels of emissions emanating from the various sectors. Figure 1.1 in chapter 1 provides some idea of the overall contribution of each sector to the resultant dose.

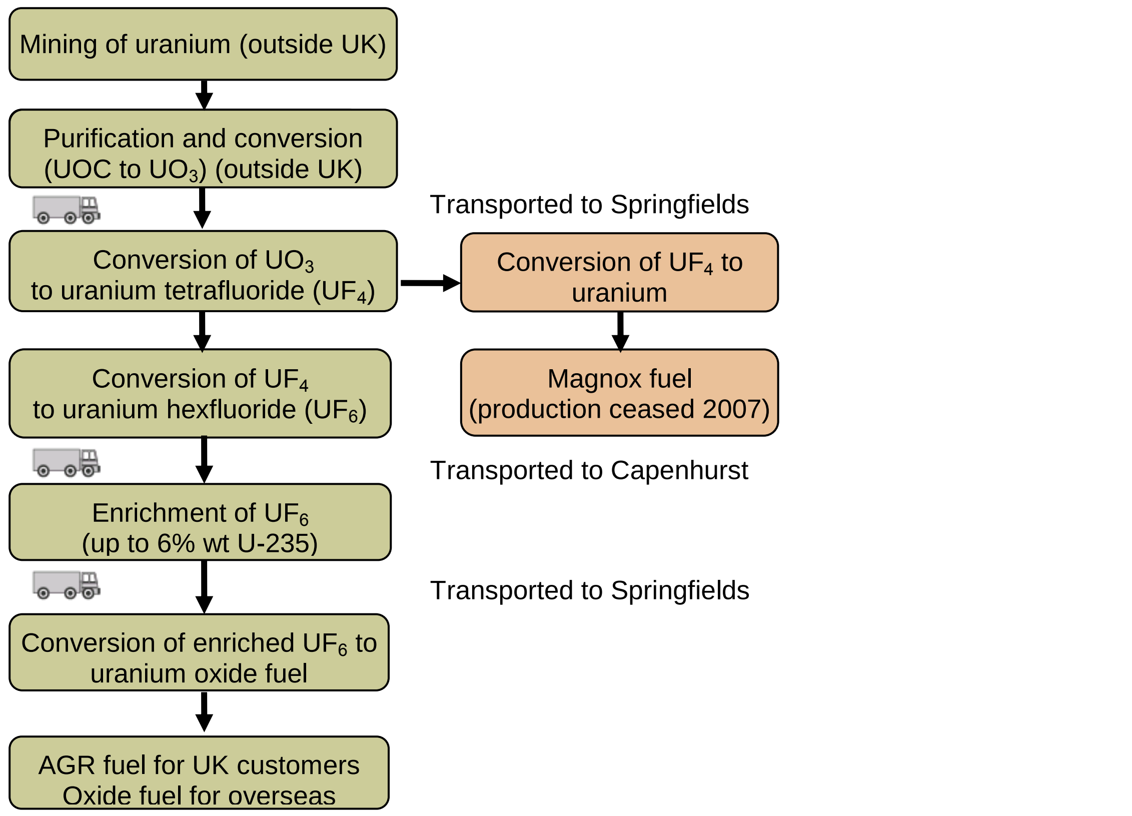
Chapter 7 - Nuclear fuel manufacture and uranium enrichment sector

7.1 Nuclear fuel elements for nuclear reactors are manufactured at the Springfields site in Lancashire (operated by Springfields Fuels Ltd) (see map 2). Uranium is enriched at the Urenco (UK) Limited (UUK) site in Cheshire. On the adjacent NDA-owned site Sellafield Ltd has responsibility for dismantling the redundant gaseous diffusion plant and associated facilities. MOX for overseas customers, using plutonium separated from reprocessing of spent fuel, is manufactured at the Sellafield site. Profiles for each of these three sites are shown on the following pages.

7.2 As shown in Figure 7.1, Springfields Fuels Ltd imports uranium trioxide (UO_3), which passes through a number of chemical processes that convert it to uranium tetrafluoride (UF_4). For the production of fuel for AGRs the UF_4 is converted into UF_6, which is sent for enrichment at the UUK site. The enrichment process increases the content of fissile uranium-235 in the UF_6 up to 6%, after which it is returned to Springfields for conversion into uranium oxide fuel for AGRs.

7.3 The production of Magnox fuel and conversion of UF_4 to uranium metal ceased in 2007 owing to the scheduled closure of the remaining Magnox power stations (see Chapter 8).

Figure 7.1 – Nuclear fuel manufacture and enrichment process



Nuclear fuel production & uranium enrichment sector - Springfields site	
 Image supplied courtesy of Springfields Fuels Ltd.	
Location	Springfields, Preston, Lancashire
Ownership	The site is owned by the NDA and is operated by Springfields Fuels Ltd. (a subsidiary of Westinghouse).
Current use	Nuclear fuel manufacture has taken place on the site since the 1940s. There is also a small research facility on the site which is currently used by a tenant, National Nuclear Laboratory.
Decommissioning Plans	To ensure robust costed plans for the decommissioning of the site are in place, the current site lifetime plan assumes that fuel manufacture on site will cease in 2024 and based on this assumption site restoration would be completed by 2031. For consistency with these plans and to describe predicted decommissioning discharges from the site, these assumptions have been used to underpin predicted future discharges. However, the operational life of the Springfields plant and consequent discharges will be determined by the commercial viability of fuel manufacture at the site and the strategic use of the site to process legacy material. It is also possible that projected discharges could be affected by future decisions by the UK Government regarding the status of separated uranium and plutonium. The NDA has been undertaking a review of nuclear materials options to inform such government decisions. A report summarising the initial outcome of this review is available on the NDA's website (www.nda.gov.uk).

Nuclear fuel production & uranium enrichment sector - Springfields site		
Liquid discharges		
Main source of discharges	Commercial operations, residue processing (including recovery of uranium) and treatment of legacy material.	
Radionuclides reported under RSA93 in RIFE-13	Alpha, beta, Tc-99, thorium-230 (Th-230), Th-232, neptunium-237 (Np-237), other transuranic radionuclides, uranium.	
Abatement technology currently used by the operator	Uranium is recovered from the effluent and through chemical and physical processing it is eventually fed back into the process. Acid discharges are subject to pH adjustment to ensure that effluent meets the specifications of the site discharge permit.	
Aerial discharges		
Main source of discharges	Commercial operations, decommissioning and dismantling of buildings.	
Radionuclides reported under RSA93 in RIFE-13	Uranium, tritium, C-14, other alpha and beta radionuclides.	
Abatement technology currently used by the operator	Filtration systems and scrubbers	
Dose to critical group (excluding contribution from Sellafield site)	2007 (calculated by site operator) – 0.007 mSv/yr	2030 (prospective dose calculated by site operator) – 0.003 mSv/yr
Other abatement technologies considered by site operator	Springfields has re-assessed the cost of installing beta decay storage at over £1 million, with resultant liquid beta discharge reductions, principally thorium and protactinium, of up to 8.4 TBq per year until 2010. As a result, given the low level of discharges subsequent to the shutdown of mainline ore processing, Springfields do not currently consider this technology to be appropriate and it would not have a significant effect on reducing estimated critical group doses or environmental concentrations.	
Other comments	Total-alpha discharges to the River Ribble declined significantly between 1980 and 2000 due to the operation of uranium recovery plants and the selective processing of low thorium containing grades of uranium ore concentrate.	

Nuclear fuel production & uranium enrichment sector - Springfields site	
2002 Strategy targets	The 2002 Strategy contained a target to cease the production of Magnox fuel and uranium hexafluoride at Springfields. The production of Magnox fuel ceased in 2007 meeting the first part of this target. The production of uranium hexafluoride continues on the site using imported UO_3, but the conversion of uranium ore concentrate to UO_3 ceased in 2006. The cessation of these operations has reduced liquid alpha discharges by 45% and liquid beta discharges by 95%, so enabling the significant reduction of discharges anticipated in the 2002 Strategy to be achieved.
Discharge projections	As described above projected discharges from the Springfields site are based on closure of operations in 2024 and completion of decommissioning in 2031, as set out in the current lifetime plan. Should operations continue on the site beyond 2024, operational discharges are expected to be no greater than those projected in the period 2020-2025. Nuclear fuel production & uranium enrichment sector projections – see Figures 7.2 to 7.6.

Nuclear fuel production & uranium enrichment sector – Capenhurst site	
 Image supplied courtesy of British Nuclear Group Ltd.	
Location	Capenhurst, Cheshire
Ownership	The Capenhurst facility is split into two separate sites. That owned and operated by URENCO (UK) Limited (UUK) includes all operational facilities, while the other focuses on decommissioning and nuclear materials storage and is operated by Sellafield Ltd under NDA ownership.
Current use	The operational enrichment facilities have been operated by UUK for the enrichment of UF_6 (to increase uranium-235 content up to 6% by weight) since 2008 (prior to this, the site was operated by BNFL from 1982 to 2008). Decommissioning of redundant gaseous diffusion plant is being undertaken by Sellafield Ltd. The Sellafield Ltd operated part of the site is also used for the storage of uranium stocks.
Site closure target	No current planned closure dates for operational facilities.
Liquid & aerial discharges	
Main source of discharges	Commercial uranium enrichment operations and decommissioning of gaseous diffusion plant. Only small amounts of liquid wastes are discharged from the site.
Radionuclides reported under RSA93 in RIFE-13	Liquid – tritium, uranium, uranium daughters, non-uranic alpha, Tc-99. Aerial – tritium, uranium.
Abatement technology currently used by the operator	1) The fitting of a dry scrubber, in place of a wet scrubber, to the waste incinerator has resulted in virtually no liquid discharges from decommissioning activities.

Nuclear fuel production & uranium enrichment sector – Capenhurst site		
	2) A mix of feeder and scrubber systems and High Efficiency Particulate in Air (HEPA) filters is used to clean gases of various radionuclides and particulate matter.	
Dose to critical group	2007 – 0.007 mSv/yr (highest dose received by children playing near brook)	2030 (prospective dose calculated by site operator) – <0.001 mSv/yr
Other abatement technologies considered by site operator	Replacing feed and wet scrubber systems with HEPA filter based systems to eliminate liquid discharges from the scrubbers in the oldest plants is being considered, together with improvements to existing HEPA filters to improve filter efficiency and reduce gaseous discharges.	
Other comments	In addition to new modules being constructed on the latest enrichment plant, Urenco are also considering carrying out the following activities before 2030: 1) Construction and operation of a Tails Deconversion Plant and associated facilities comprising cylinder washing, residue recovery, decontamination and maintenance. 2) Enrichment of recycled uranium. Operations are anticipated to commence in 2012 subject to regulatory approval; 3) Enrichment of uranium to a higher assay for future generations of nuclear power stations; 4) Construction of a Centralised Waste Management Facility; and 5) Possible decommissioning of old centrifuge enrichment plants.	
Discharge projections	Nuclear fuel production & uranium enrichment sector projections – see Figures 7.2 to 7.6.	

Nuclear fuel production & uranium enrichment sector – Sellafield MOX Plant	
 Image supplied courtesy of British Nuclear Group Ltd.	
Location	Sellafield, Cumbria
Ownership	The Sellafield MOX Plant (SMP) is part of the Sellafield Site operated by Sellafield Ltd and owned by the NDA.
Current use	The SMP manufactures mixed (uranium and plutonium) oxide fuel, using plutonium separated in THORP (Chapter 9) and belonging to overseas customers.
Site closure target	No current planned closure date
Liquid and aerial discharges	
Main source of discharges	The SMP utilises a dry process, which results in negligible liquid discharges. Wash water from maintenance, personal hygiene and laundries accounts for the bulk of the small amount of liquid waste discharged. Aerial discharges arise primarily from plant filtered ventilation systems.
Radionuclides reported under RSA93	Reported as part of the Sellafield site discharges (Chapter 9)
Abatement technology currently used by the operator	HEPA filters
Dose to critical group	2007 – 3 x 10^{-9} mSv/yr (calculated by site operator)
Discharge projections	Discharges from SMP are very minor and are therefore included in the discharge profiles for Sellafield (Chapter 9).

7.4 Sector discharge projections

Discharge projections – nuclear fuel manufacture and uranium enrichment sector	
Discharge Projections	The projected liquid and aerial discharge profiles to 2030 for the nuclear fuel production and uranium enrichment sector are shown at Figures 7.2 to 7.6 below.
Overall comments	Liquid discharges from the nuclear fuel production and uranium enrichment sector have declined substantially since 1995, particularly with the cessation of uranium ore conversion at Springfields in 2006. Based on current plans discharges are predicted to reduce further during the time frame to 2030. Future discharges from the nuclear fuel production and uranium enrichment sector will depend on the demand for nuclear fuels. Uranium hexafluoride production is expected to continue at the Springfields site into the future as part of the process of fuel manufacture for AGRs, but will continue to use imported UO_3 to avoid the need for on-site ore conversion.
2009 Strategy expected outcomes	The outcomes described below have been predicted on the basis that the Springfields site will cease operation in 2024. Should operations continue on the site beyond that date, operational discharges are expected to be consistent with those projected in the period 2020-2025. By 2020: • total-alpha (liquid) discharges are expected to have reduced from 0.08 TBq/yr to below 0.04 TBq/yr. • total-beta (liquid) discharges are expected to have reduced from around 20 TBq/yr to below 0.7 TBq/yr. By 2030: • on the assumption that Springfields will no longer be operational, total-alpha (liquid) discharges are expected to have reduced to below 0.004 TBq/yr. • on the assumption that Springfields will no longer be operational, total-beta (liquid) discharges are expected to have reduced to below 0.005 TBq/yr. • Otherwise discharges are expected to be consistent with those projected in the period 2020 to 2025.

Figure 7.2: Total alpha discharges from nuclear fuel production and uranium enrichment sector (liquid)

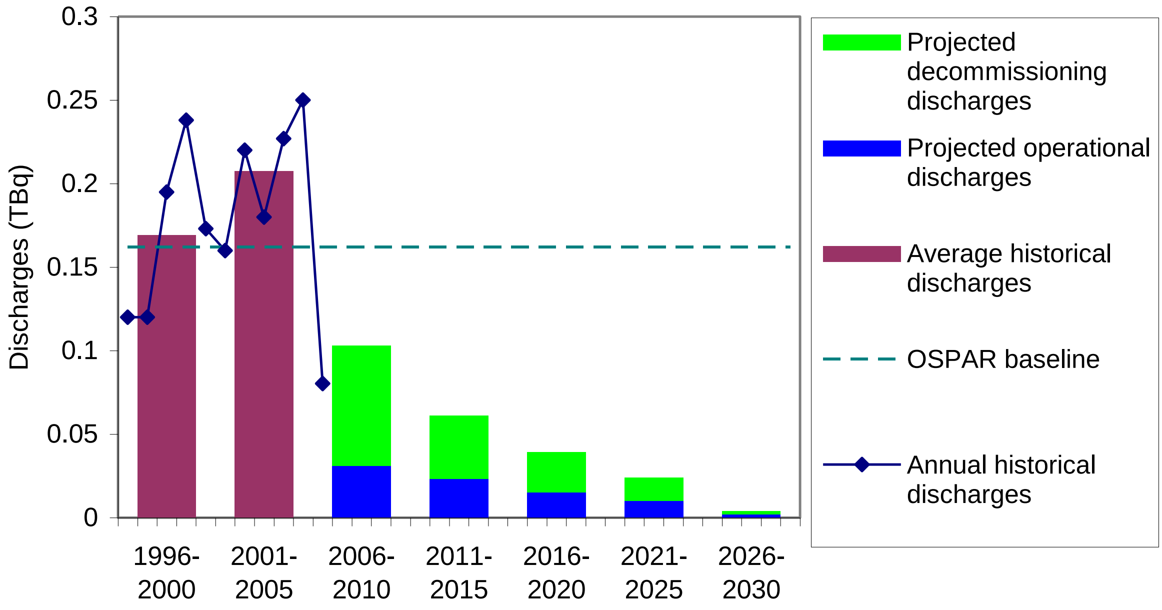


Figure 7.3: Total beta discharges from nuclear fuel production and uranium enrichment sector (liquid)

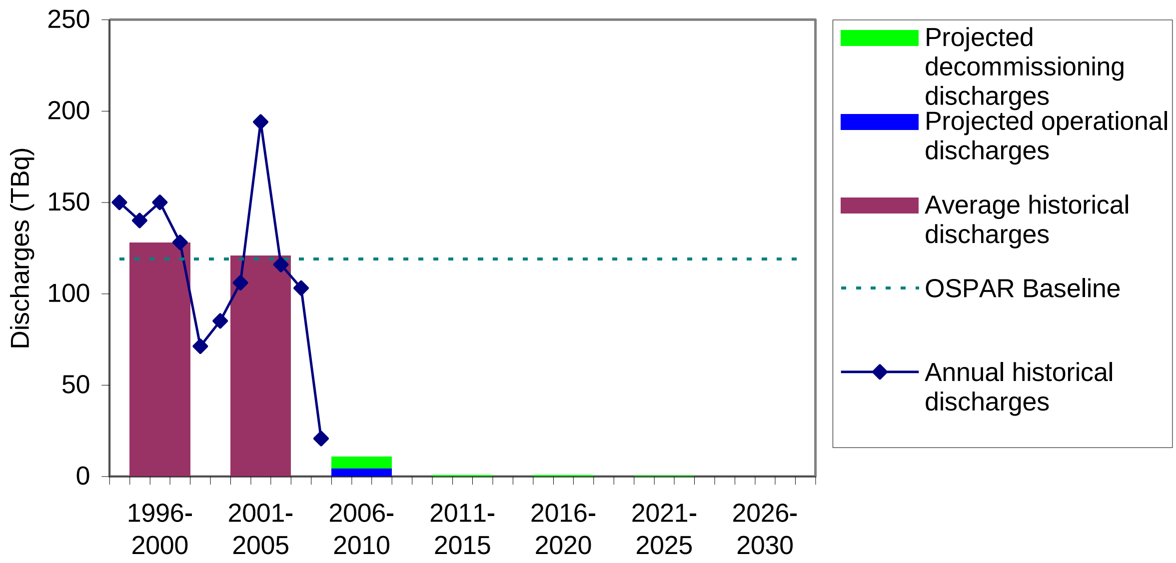


Figure 7.4: Total alpha discharges from nuclear fuel production and uranium enrichment sector (aerial)

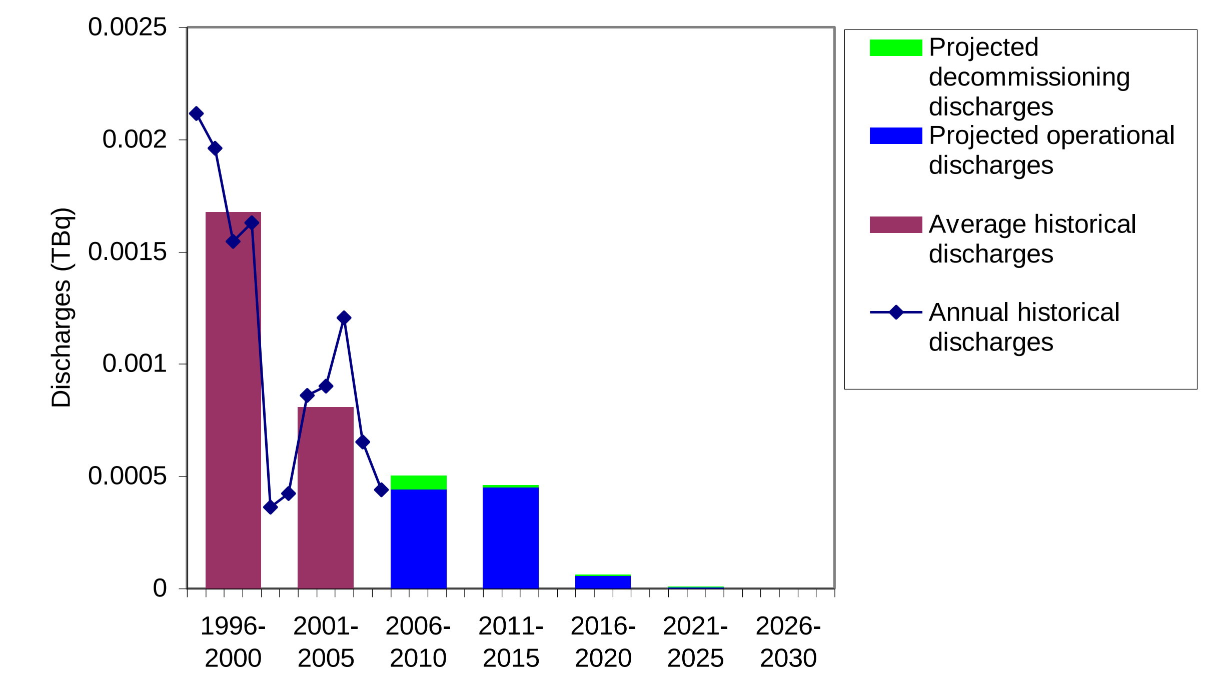
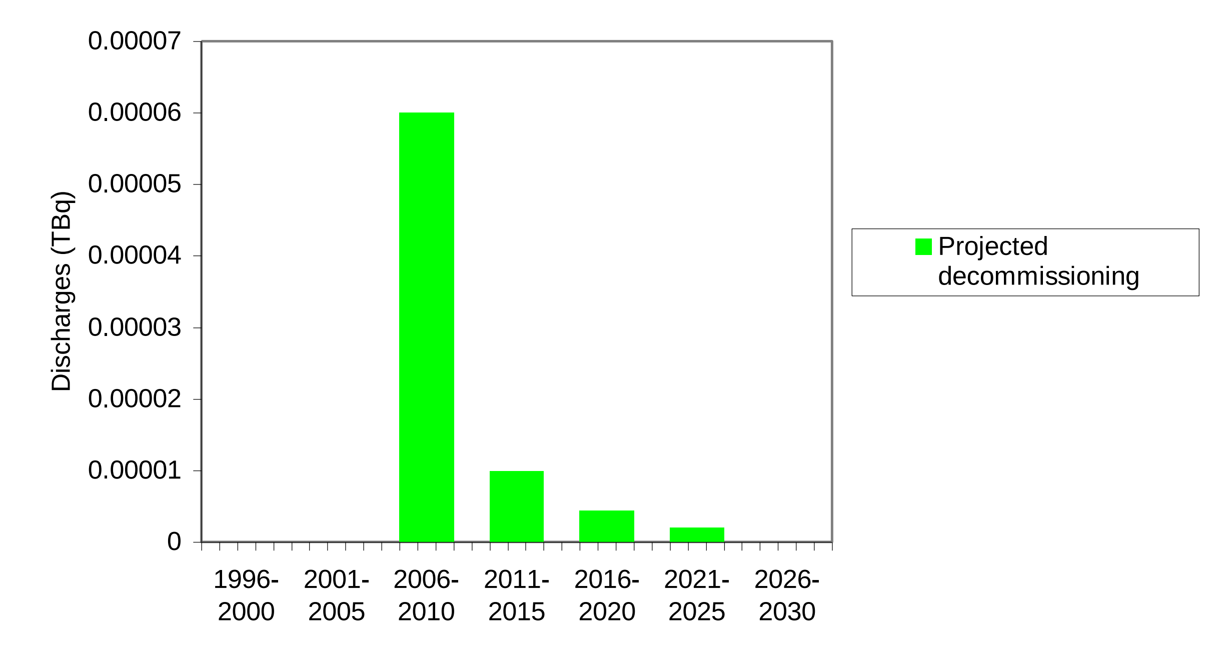
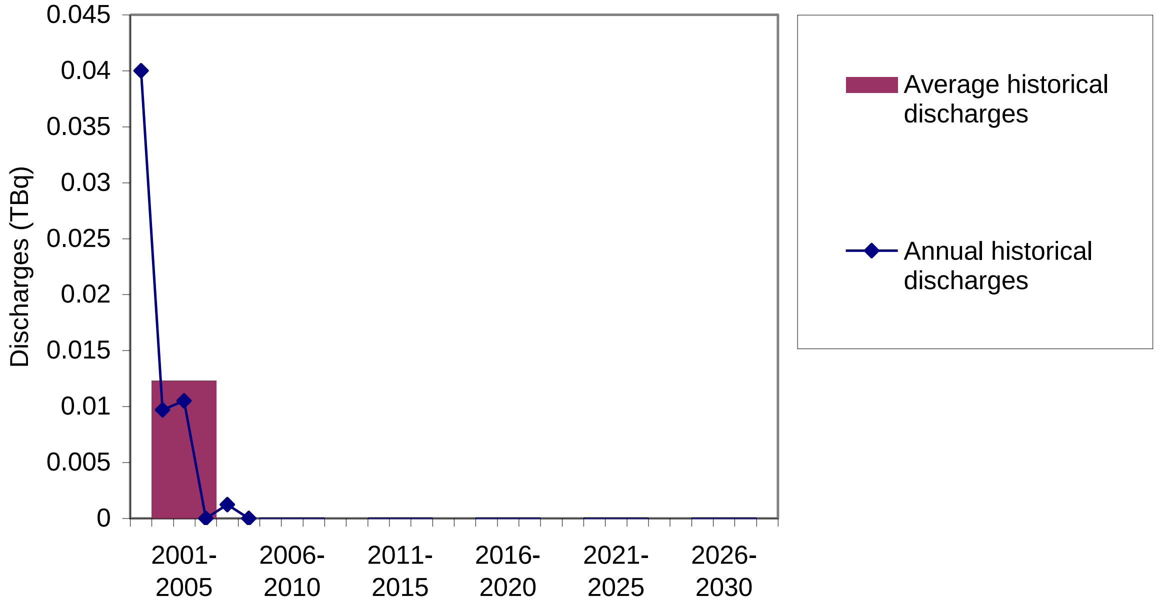


Figure 7.5: Total beta discharges from nuclear fuel production and uranium enrichment sector (aerial)



*Aerial beta discharge data not required under site authorisations.

Figure 7.6: H-3 discharges from nuclear fuel production and uranium enrichment sector (aerial)



*Historical discharges greater than projected discharges (2006-2030 (operational) 4.2E-05 TBq/yr, 2006-2030 (decommissioning) 0.0 TBq/yr).

Chapter 8 - Nuclear energy production sector

8.1 Nuclear energy currently accounts for about 15% of the UK's electricity production. The Government wishes to maintain a diversity of power sources in the UK and is committed to meeting its targets on the reduction of carbon dioxide emissions. Following a public consultation in 2007[33] the Government published "Meeting the Energy Challenge: A White Paper on Nuclear Power" in January 2008 ("the White Paper"). In the White Paper, the UK Government concluded that "new nuclear power stations should have a role to play in this country's future energy mix alongside other low-carbon sources; that it would be in the public interest to allow energy companies the option of investing in new nuclear power stations; and that the UK Government should take active steps to facilitate this". Chapter 6 explains how this Strategy will take into account the effect of new nuclear build.

8.2 Most of the currently operating nuclear power reactors in the UK are of the gas-cooled type (either the earlier Magnox reactor or the later AGR). These commenced generation between 1956 and 1988. A single Pressurised Water Reactor (PWR) started operation at the Sizewell "B" site in 1995. The locations of nuclear power stations are shown on Map 1.

8.3 Of the eleven Magnox nuclear power stations built in the UK two remain operational. The closure of the Magnox stations commenced in 1989 however an accelerated closure programme was initiated in 2000 to support national and international discharge obligations, and to ensure best available use of existing Magnox reprocessing facilities. It is currently anticipated that the last Magnox station will close in December 2010. Five Magnox reactors have already been defuelled and decommissioning operations have commenced.

8.4 Defuelling and decommissioning strategies for Magnox stations and other UK civil nuclear facilities are the responsibility of the NDA. The Magnox defuelling programme has recently been revised and is described in the January 2009 issue of the Magnox Operating Programme (MOP8) which can be obtained from the NDA at www.nda.gov.uk. The previous assumption that spent Magnox fuel reprocessing will be completed by the end of 2012 has been revised to January 2016 or later owing to shortfall in reprocessing performance at Sellafield and reflecting more conservative planning assumptions. As a consequence, the NDA is considering whether the two operational Magnox stations (Oldbury and Wylfa) could continue generation beyond their current closure dates without significantly affecting the time taken to complete Magnox reprocessing. The impact on Magnox reprocessing will be fully considered in the review of this opportunity.

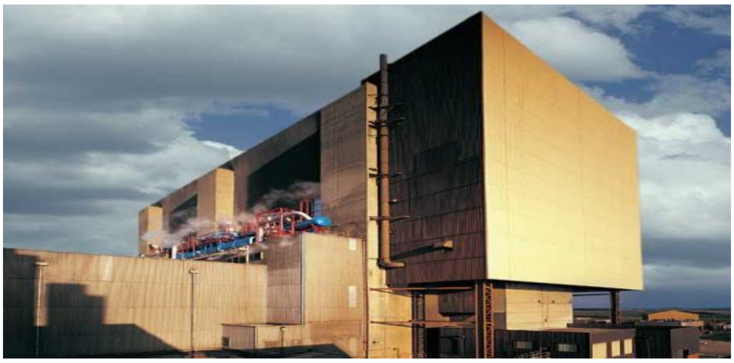
[33] The Future of Nuclear Power – The Role of Nuclear Power in a Low Carbon UK, Department of Trade & Industry, 2007.

Nuclear energy production sector – Magnox power stations	
 Image supplied courtesy of Magnox Electric	
Location	There are 11 Magnox gas-cooled power stations across the UK; 10 of these sites have ceased power production and are at different stages of decommissioning. Of these, 5 have been completely defuelled. The one remaining operational site, Wylfa, is currently expected to cease operation in December 2010.
Ownership	All of the Magnox reactor sites are operated by Magnox Electric Ltd, with the exception of the Calder Hall site which is operated by Sellafield Ltd. All are owned by the NDA.
Decommissioning plans	The current reactor decommissioning plans are based on the following phases: 1) Defuelling: Provided that reprocessing capacity is available at Sellafield, sites will be defuelled as soon as practicable after cessation of electricity generation. Where reprocessing capacity is constrained then fuel will remain in reactors until reprocessing capacity is available. This will minimise the time that fuel is stored wet, in order to minimise consequent discharges from the fuel cooling ponds. 2) Care and Maintenance (C & M) preparations: All buildings except the reactor buildings will be decontaminated and demolished and the reactor buildings will be put into “Safestore”, making them weather and intruder resistant for the extended C & M period. All operational Intermediate Level Waste (ILW), except for Miscellaneous Activated Materials (MAM) and desiccants, will be retrieved, packaged for final disposal and transferred to on-site interim ILW stores. Desiccants will be transferred to

Nuclear energy production sector – Magnox power stations	
	containers for storage. MAM will be safely contained within storage locations inside concrete vaults (except at Trawsfynydd – see below); it will be retrieved for disposal during reactor dismantling. At Trawsfynydd, MAM will be stored in the on-site ILW store following retrieval and encapsulation in concrete. 3) C & M: During this period, reactor sites will remain in a state of passive safety for about 100 years from cessation of generation. Sites will continue to be monitored and maintained to ensure they remain in a passively safe and secure state.
Decommissioning target dates	More detailed information on the decommissioning plans for the Magnox sites is available on the NDA website at www.nda.gov.uk.
Liquid discharges	
Main source of discharges	Except at Wylfa power station, which has a dry store, spent fuel is stored in cooling ponds, prior to being sent to Sellafield for interim storage and reprocessing. The major source of liquid alpha and beta discharges from Magnox stations is the corrosion and subsequent leakage of fuel elements in the cooling ponds. The main source of liquid tritium discharges is tritium build-up in desiccant used to capture water vapour (produced from processes to minimise oxidation of the graphite moderator). The desiccant is recycled by driving off the water it has absorbed, along with the tritium and other radionuclides contained within it. Following shutdown and defuelling, the main source of arisings is likely to change. Dependent upon the site, future arisings will be mainly from treatment and disposal of radioactive wastes, including generation of secondary wastes, and potentially liquid discharges resulting from contaminated land issues.
Radionuclides reported under RSA93 in RIFE-13	H-3, Cs-137 (except Chapelcross, Hunterston A & Wylfa), alpha & beta (Chapelcross & Hunterston A only), Pu-241 (Hunterston A only), Sr-90 (Trawsfynydd only), other radionuclides (except Chapelcross & Hunterston A).

Nuclear energy production sector – Magnox power stations		
Liquid discharges (continued)		
Abatement technology currently used by the operator	1) Caesium removal units - beds of ion exchange resin are used to reduce the amount of caesium and other radionuclides in cooling pond water and other liquid effluents. However, the used resin cannot be recycled and is stored as solid ILW. Use of these units to further reduce discharges must therefore be balanced with the need to minimise worker doses due to the management of these ILW wastes. Magnox Electric Ltd has started to use higher capacity ion exchange resins, which has reduced the volume of ILW solid waste arisings. 2) Sand pressure filters are used for particulate control.	
Aerial discharges		
Source of discharges	Alpha and beta discharges - While a reactor is operational and during defuelling, the main sources of aerial discharges are releases from the nuclear fuel within the reactor and the activation of graphite and metallic components within the reactor core. Once reactors are defuelled, aerial discharges are expected to be very low, primarily from releases of C-14 and H-3 from the reactor core graphite and metallic components. Prior to entry into the C & M period, aerial discharges also result from decommissioning and decontamination of structures and the processing of radioactive wastes.	
Radionuclides reported under RSA93 in RIFE-13	H-3, beta (except Chapelcross), C-14 (except Chapelcross), sulphur-35 (S-35) (except Berkeley, Bradwell, Hinkley Point A, Hunterston A & Trawsfynydd), Ar-41 (Chapelcross, Dungeness A, Oldbury, Sizewell A & Wylfa only).	
Abatement technology currently used by the operator	HEPA filtration is used where appropriate.	
Dose to critical group (excluding external radiation)	Operational Generally <0.005 mSv/yr. Highest dose (Heysham) seafood consumers 0.037 mSv/yr. (From both Magnox & AGR stations)	Decommissioning Generally <0.005 mSv/yr. Highest dose (Chapelcross) consumers of locally grown food 0.024 mSv/yr.

Nuclear energy production sector – Magnox power stations	
Other abatement technologies considered by site operators	The following abatement technologies are currently being considered: 1) Improvement of ion exchange systems, including management of pre- and post- filter systems. 2) Physical filtration techniques to control particulates, centrifuge systems for sedimentation and filtering designs.
Other comments	Any acceleration of final site clearance, based on the conditions that applied as at 31 August 2007, would potentially produce higher aerial discharges of a wide range of radionuclides. Higher liquid discharges are not anticipated from final site clearance. Alternative options to reduce the amount of operational ILW prior to disposal (including fuel element debris and ion exchange resins and sludge) such as chemical and thermal treatment could result in short-term increases in aerial and liquid discharges.
Discharge projections	Nuclear energy production sector projections – see Figures 8.1 to 8.6.

Nuclear energy production sector – AGR power stations	
 Image supplied courtesy of British Energy, part of EDF Energy	
Location	7 operational power stations with twin AGRs
Ownership	British Energy Group plc
Closure programme	See Table 8.1
Liquid discharges	
Main source of discharges	Over 99% of total radioactive discharges to sea from AGR stations is due to tritium as tritiated water. Most of this tritium is a ternary fission product that diffuses through the stainless steel clad at the higher temperatures of an operating AGR. As is the case for Magnox stations, tritium builds up in desiccants used to capture water vapour produced from processes to minimise oxidation of the graphite moderator. The desiccant is recycled by driving off the water it has absorbed, along with the tritium and other radionuclides contained within it. S-35, a graphite activation product, is also present in this desiccant regeneration waste. The stainless steel fuel cladding is resistant to corrosion and the main source of liquid betaβ discharges is from the activation products present on the surfaces of the spent fuel when it is discharged to the cooling ponds. Some liquid alpha and beta discharges may be generated by spent fuel that has developed leaks before discharge from the reactor or from contamination of the fuel skips at Sellafield.
Radionuclides reported under RSA93 in RIFE-13	H-3, S-35, cobalt-60 (Co-60), Cs-137 (except Hunterston B & Torness) alpha & beta (Hunterston B & Torness only), other radionuclides (except Hunterston B & Torness), alpha & all other non-alpha (Hunterston B & Torness only).

Nuclear energy production sector – AGR power stations	
Abatement technology currently used by site operator	Ion exchange resins continue to be used to manage soluble radioactivity from the cooling ponds. This process is optimised by pre-filtration of insoluble particulate radioactivity to maximise the lifetime of the resins. Some AGR stations use fine filters for their liquid waste streams.
Aerial discharges	
Source of discharges	Alpha and beta discharges – While operational the main source of aerial discharges is C-14, S-35, Ar-41 and H-3 released by the activation of coolant, graphite and metallic components within the reactor core.
Radionuclides reported under RSA93 in RIFE-13	Beta, H-3, C-14, S-35, Ar-41, Co-60 I-131.
Abatement technology currently used by site operator	1) Activated charcoal and HEPA filtration is used where appropriate. 2) Emissions from the on-site incinerator at Hinkley Point are abated using wet gas scrubbing plant, which results in very small liquid discharges.
Dose to critical group (excluding external radiation)	Generally <0.005 mSv/yr. Highest dose (Heysham,Dungeness) seafood consumers 0.037 mSv/yr. (From both Magnox & AGR stations).
Other abatement technologies considered by site operator	Although regeneration of desiccant is currently considered to be the best environmental option, alternative options include evaporation or storage of tritiated water and storage of desiccant as ILW. However, these options would result in higher doses to workers and the public, and the risks are currently considered to outweigh any environmental benefits from reducing discharges.
Other comments	1) Contamination of the fuel pond skips transported back from Sellafield have been slightly contaminated with Cs-137 and have resulted in increased activity in the fuel ponds at the AGR power stations. The proportions of Cs-137 compared to other radionuclides have risen significantly and when the EA recently reviewed the limits for liquid discharges it reduced the limit for other radionuclides and introduced a limit for Cs-137. 2) Since the publication of the 2002 strategy, BE has extended the lifetimes of Dungeness B, Hinkley Point B and Hunterston B by 5 years.
Discharge projections	Nuclear energy production sector projections – see Figures 8.1 to 8.6.

Table 8.1: Current assumed closure dates of AGR power stations

Site	Closure date
Hartlepool	2014
Heysham 1	2014
Hinkley Point B	2016
Hunterston B	2016
Dungeness B	2018
Heysham 2	2023
Torness	2023

Nuclear energy production sector – PWR power stations	
 Image supplied courtesy of British Energy, part of EDF Energy	
Location	1 PWR located at Sizewell B, Suffolk
Ownership	British Energy Group plc
Assumed closure date	2035
Liquid discharges	
Main source of discharges	The mix of radionuclides discharged from Sizewell B is similar to that from the AGRs except that there are no discharges of S-35 and H-3 discharges are significantly lower. The principal sources of discharges are the reactor, the reactor coolant system and their associated systems.
Radionuclides reported under RSA93 in RIFE-13	H-3, Cs-137, other radionuclides.
Abatement technology currently used by site operator	Ion exchange is used to reduce the amount of radionuclides in discharges. The quality of resins has recently been improved to reduce the amount of ILW generated.
Aerial discharges	
Source of discharges	Coolant degassing
Radionuclides reported under RSA93 in RIFE-12	Halogens, beta, H-3, C-14, I-131.
Abatement technology currently used by site operator	All ventilation air from radiologically controlled areas is HEPA filtered. Charcoal absorber beds are used for the removal of radioiodine. The carbon bed delay system treats reactor off-gas, which reduces noble gas activity discharged by radioactive decay.
Dose to critical group	<0.005 mSv/yr

Nuclear energy production sector – PWR power stations	
Other abatement technologies considered by site operator	Sizewell B was constructed with two evaporators: one for recycling boric acid from the reactor coolant system, and one for abatement of liquid radioactive waste. Evaporation of liquid for either purpose is not currently considered BPM or ALARA. This is because the benefit of reducing liquid discharges, in terms of the consequent small reduction of public dose, is much less than the dis-benefit of increased operator doses. In addition, the small reduction in public dose would not justify the cost of processing (evaporator and encapsulation) and the cost of providing sufficient high quality steam to run the evaporators.
Discharge projections	Nuclear energy production sector projections – see Figures 8.1 to 8.6.

8.3 Sector discharge projections

Discharge projections - nuclear energy production sector	
Discharge Projections	The projected liquid and aerial discharge profiles to 2030 for the nuclear energy production sector are at Figures 8.1 to 8.6 below. These do not take account of possible further AGR life extensions or new nuclear build.
Overall comments	The pattern of radioactive discharges from the nuclear energy production sector until 2030 has been dominated by the power station closure programme and could be further determined by decisions taken on the operating lifetimes of the AGR reactors (chapter 6). Any further lifetime extensions would probably defer significant reductions in discharges until a later date, but would be unlikely to result in any significant increased discharges in radioactivity.
2009 Strategy expected outcomes	These expected discharge outcomes have been projected on the assumption that there will be no further extension of power station lifetimes and no new build of nuclear power stations. The potential impact of either scenario is discussed in chapter 6. By 2020: • total-alpha (liquid) discharges will be reduced from around 2E-05 TBq/yr to below 3E-04 TBq/yr. • total-beta (liquid) discharges will be reduced from around 4.5 TBq/yr to below 1.5 TBq/yr. • H-3 (liquid) discharges will be reduced from over 2000 TBq/yr to below 850 TBq/yr. • C-14 (aerial) discharges will be reduced from around 14 TBq/yr to below 3 TBq/yr. By 2030: • total-alpha (liquid) discharges will be reduced to below 6E-05 TBq/yr. • total-beta (liquid) discharges will be reduced to below 0.1 TBq/yr. • H-3 (liquid) discharges will be reduced to below 75 TBq/yr. • C-14 (aerial) discharges will be reduced to below 0.3 TBq/yr.

Figure 8.1: Total alpha discharges from nuclear energy production sector (liquid)

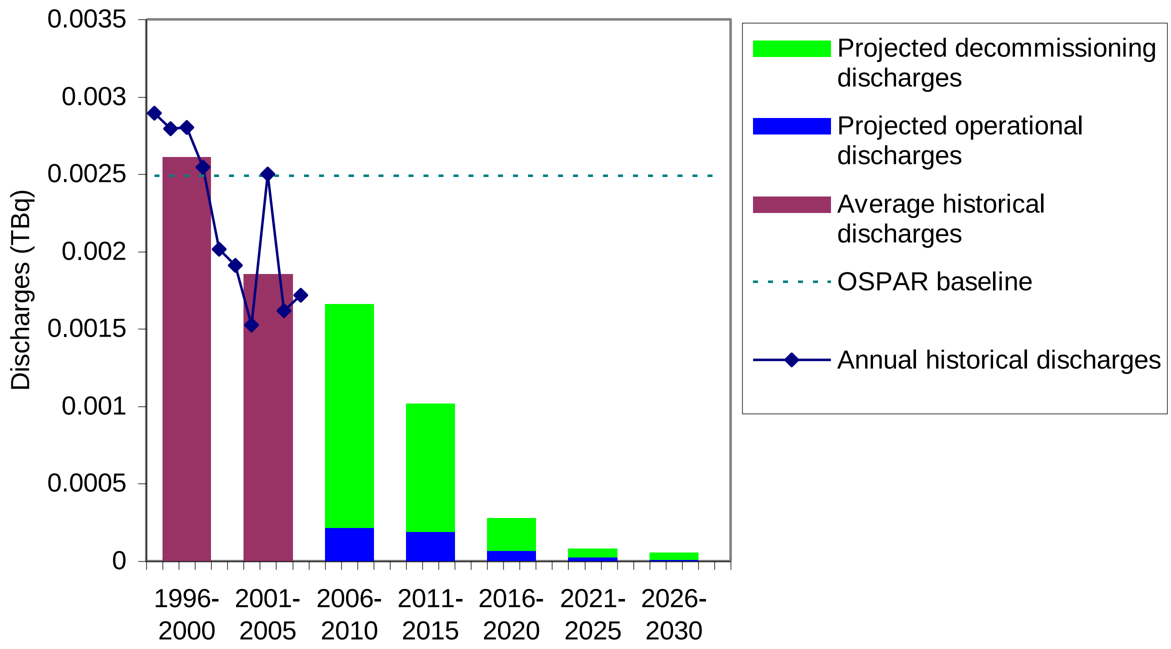


Figure 8.2: Total beta discharges from nuclear energy production sector (liquid)

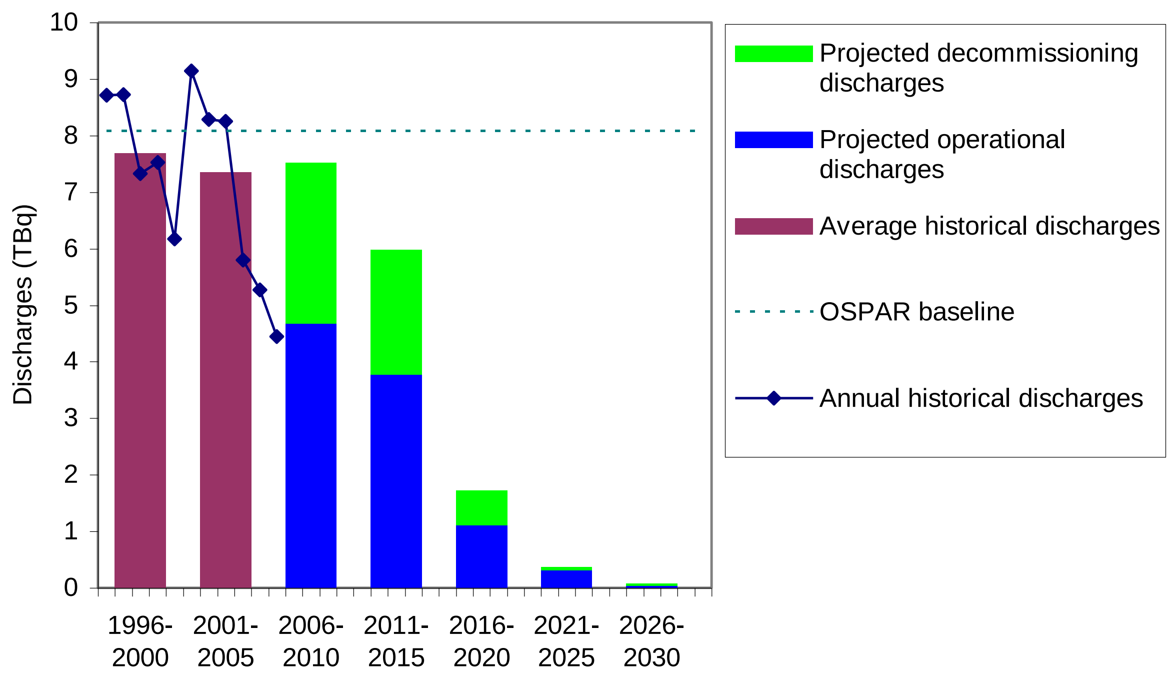


Figure 8.3: H-3 discharges from nuclear energy production sector (liquid)

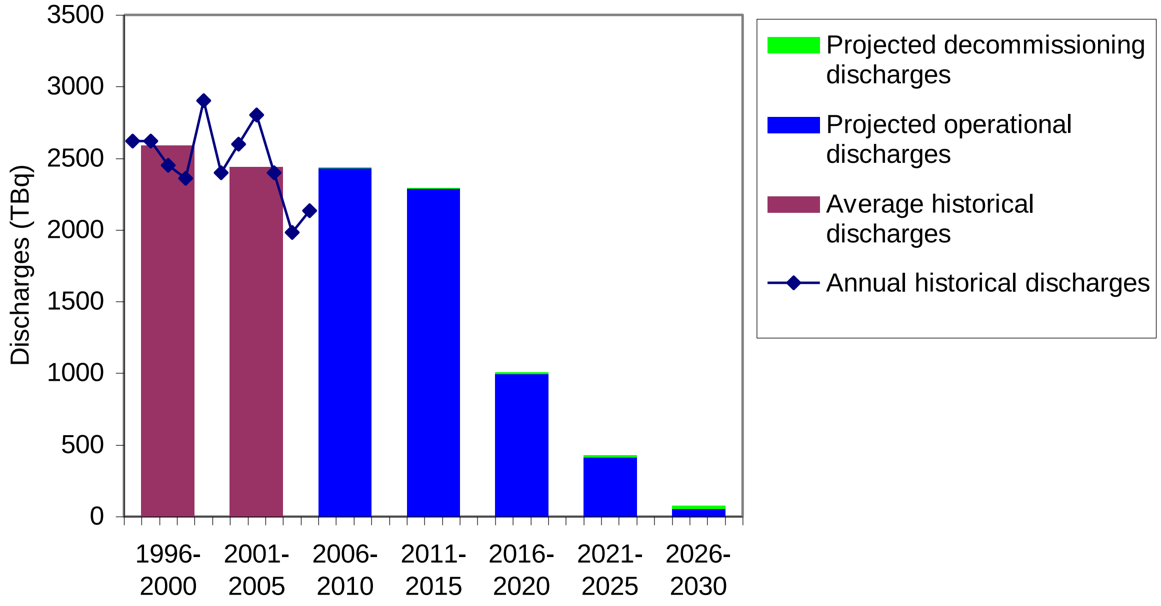


Figure 8.4: Total beta discharges from nuclear energy production sector (aerial)

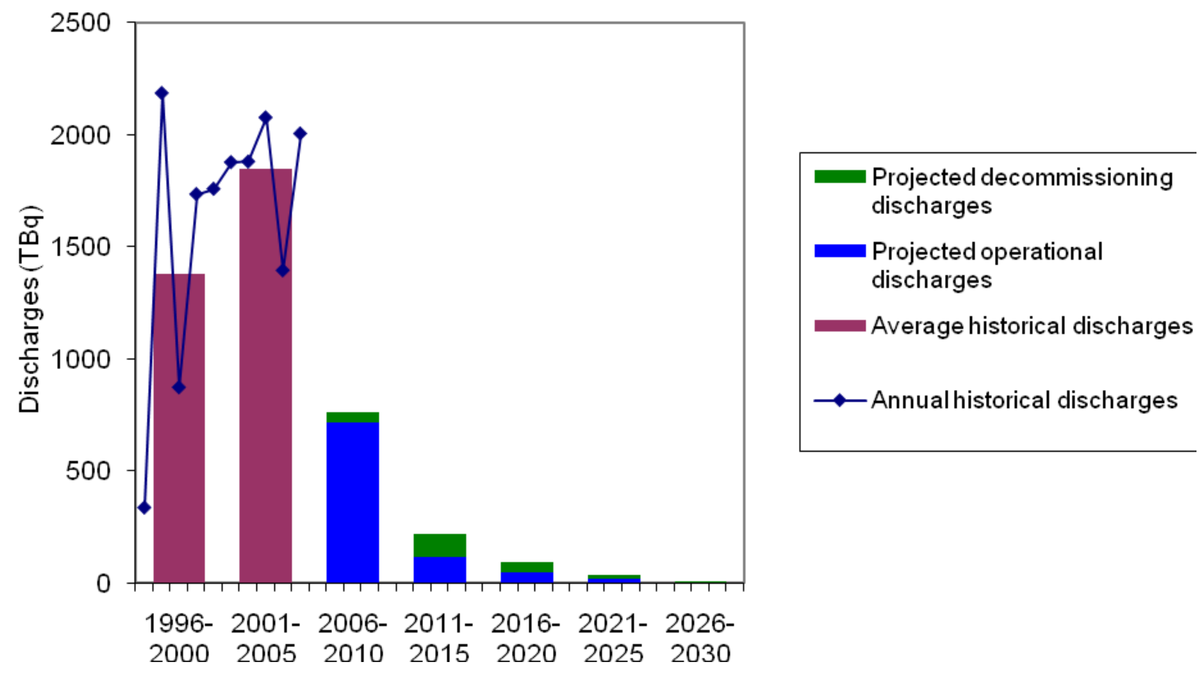


Figure 8.5: H-3 discharges from nuclear energy production sector (aerial)

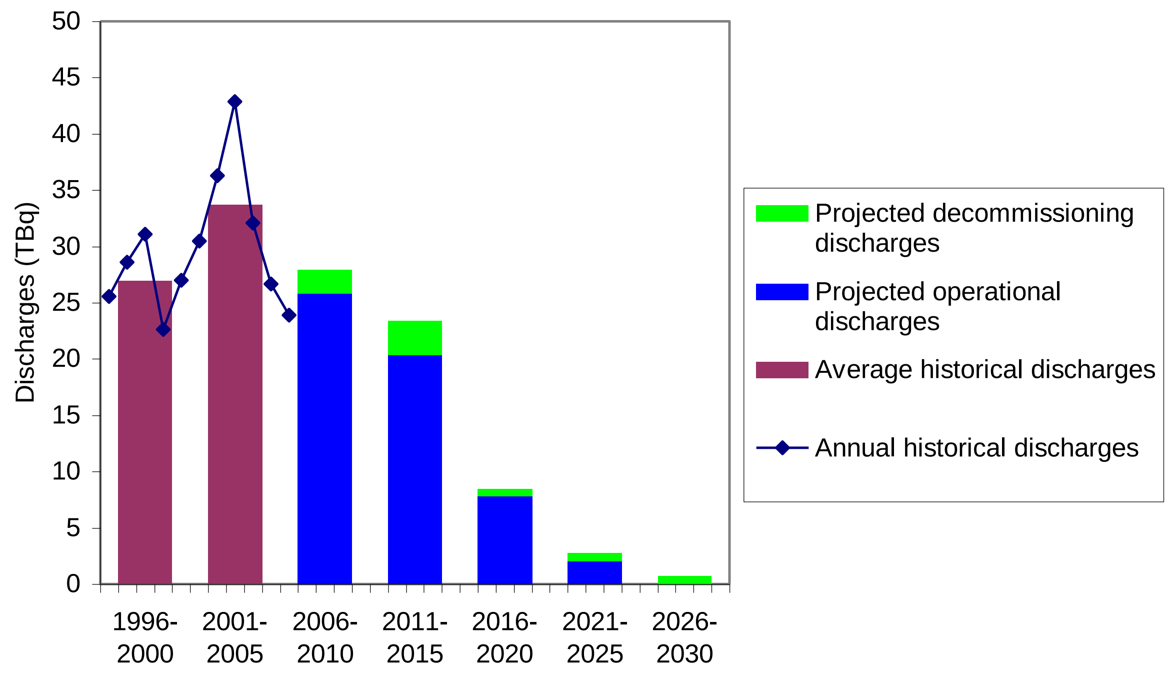
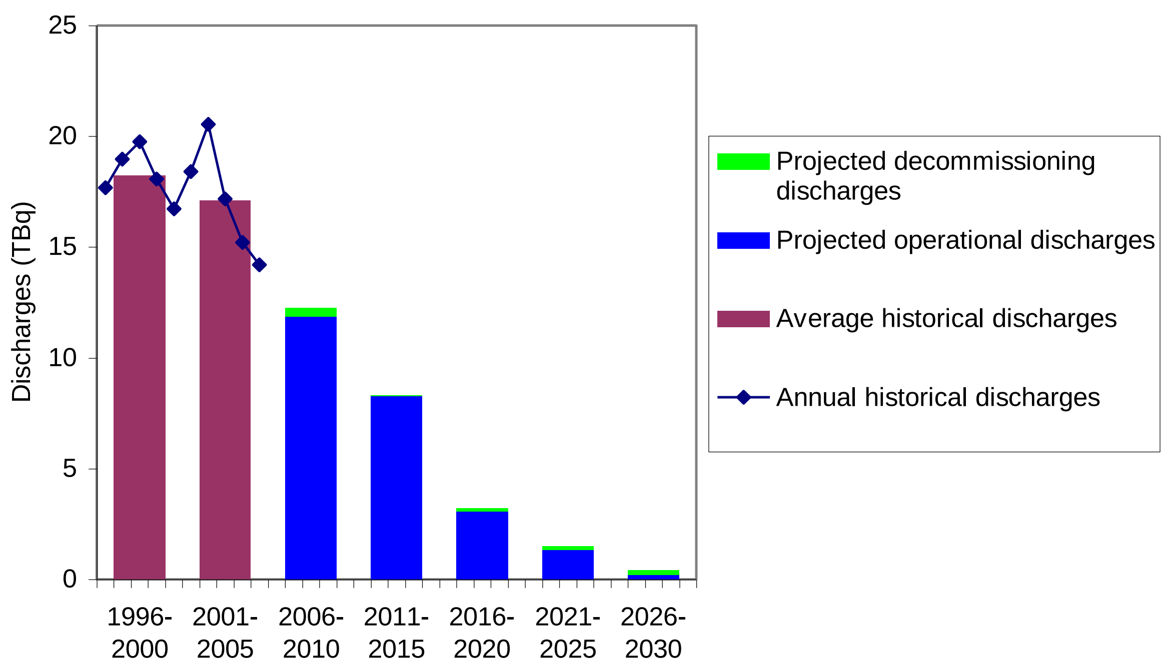


Figure 8.6: C-14 discharges from nuclear energy production sector (aerial)



Chapter 9 - Spent nuclear fuel reprocessing sector

9.1 The reprocessing of spent nuclear fuel to separate out uranium and plutonium which can be reused, from the wastes is carried out at the Sellafield site in Cumbria (see Box 4). The site is the largest nuclear complex in the UK, and is operated by Sellafield Ltd on behalf of its owner, the NDA.

9.2 The Sellafield site has a long history, dating back to the 1950s, covering a wide range of nuclear activities. The primary activities currently undertaken at Sellafield are:

- reprocessing of spent nuclear fuels from UK and overseas nuclear power plants;
- small scale manufacture of mixed oxide fuels – see chapter 6 for details;
- the management of historic, stored wastes;
- the decommissioning and clean-up of redundant facilities; and
- nuclear research – see chapter 10 for details.

Box 4 – What is reprocessing?

The average life of a nuclear fuel rod in a reactor is about four years, after which time most of its readily fissile content has been used up and become waste products. Used or “spent” fuel rods are removed from the reactor core and replaced by new ones. The spent fuel can be reprocessed to separate out the uranium and plutonium, which can be re-used, from the wastes.

Two main types of spent fuel are reprocessed at Sellafield: Magnox fuel from the first generation of nuclear power station reactors and oxide fuels from AGRs in the UK and light water reactors from overseas.

Magnox fuel reprocessing

The name Magnox comes from the magnesium alloy casing which surrounds a uranium metal fuel rod, to keep fission products contained within the casing. Spent Magnox fuel rods are received into the Fuel Handling Plant (FHP), where they are stored in water-filled ponds. The fuel rods are stripped of their cladding (decanned) and sent to the Magnox separation plant, where they are dissolved in nitric acid. Uranium (about 96%) and plutonium (less than 1%) are extracted from the resulting solution as nitrates and are then converted into more stable oxides. Radioactive waste products (less than 1%) remain in the solution, which is volume-reduced, then converted to a solid, glass-like form (vitrified) and stored safely. A small proportion of the original radioactive material is processed via other routes, generating both intermediate and low level solid wastes and liquid and aerial discharges.

Thermal oxide reprocessing

Spent uranium oxide fuel is initially unpacked and stored in the receipt and storage facility, before being transferred to THORP. Here, both stainless steel and zircalloy fuel pins, containing uranium oxide fuel pellets, are sheared into short lengths and the fuel pellets are dissolved in hot nitric acid. As with Magnox fuel reprocessing, uranium and plutonium are extracted and the remaining waste is vitrified.
The extracted uranium from both Magnox and THORP reprocessing operations can be used to manufacture new nuclear fuel. The plutonium is currently stored but that belonging to foreign customers, that has been recovered through THORP, may be used in the production of MOX fuel in the SMP and returned to them in this form.

9.3 Since the 1970s, the operators of the Sellafield site have secured major reductions in radioactive discharges and associated potential impacts. This has partly been achieved by changes in operational practices, but more by virtue of a substantial programme of waste management and effluent treatment plants which have progressively come into operation over the past 20 years. The principal low level radioactive liquid effluents from the Sellafield site are discharged via marine pipelines, which extend some two miles off the coast adjacent to the site. The effluent treatment plants include the Site Ion Exchange Plant (SIXEP) and the Enhanced Actinide Removal Plant (EARP). The reprocessing of Magnox fuel produces a liquid concentrate containing Tc-99 and other, more radiotoxic radionuclides such as plutonium and americium. This is known as medium active concentrate, or MAC, and prior to 1981 it was simply discharged into the sea after several years of decay storage. The treatment of stored MAC in EARP, prior to discharge, has reduced radioactive discharges to sea and other changes have recently been made to significantly reduce liquid discharges of Tc-99.

9.3.1 Additionally, with the introduction of new facilities, which will provide further treatment measures for stored wastes, and a continuing programme of safe maintenance and post-operational clean-up, discharges are expected to follow a general trend of further reduction. However, some short-term increases in discharges may be unavoidable, mainly associated with the processing of the legacy of stored wastes into safer forms suitable for long term storage and disposal. A significant amount of work associated with historical waste management and decommissioning activities will continue beyond 2030.

9.3.2 Current liquid and aerial discharges arise mainly from the two reprocessing plants, their associated spent fuel storage ponds and downstream plant, and to a lesser extent from decommissioning and clean-up activities on the site.

9.3.3 This section includes information on projected discharges from the Sellafield site. These include all operational and decommissioning discharges from Sellafield, not just those resulting from spent nuclear fuel reprocessing.

Spent nuclear fuel reprocessing sector - Sellafield	
 Image supplied courtesy of British Nuclear Group Ltd.	
Location	Seascale, Cumbria
Ownership	The site is operated by Sellafield Ltd and owned by the NDA.
Decommissioning plans	An overview of the current decommissioning plans for the Sellafield site is available on the NDA website www.nda.gov.uk.
Liquid discharges	
Main source of discharges	Fuel ponds, Magnox and THORP reprocessing and associated downstream plants, clean-up of legacy facilities and decommissioning activities. Discharges to sea via groundwater.
Radionuclides reported under RSA93 in RIFE-13	Alpha, beta, H-3, C-14, Co-60, Sr-90, zirconium 95 & Nb-95, Tc-99, ruthenium-106 (Ru-106), I-129, Cs-134, Cs-137, cerium-144 (Ce-144) , Np-237, plutonium alpha, Pu-241, Am-241, curium-243 & 244 (Cm-243 & 244), uranium.
Abatement technology currently used by site operator	1) **Highly Active Liquor Evaporation and Storage (HALES) & vitrification:** The highly active liquid waste that arises from both reprocessing plants is evaporated to reduce its volume, and subsequently stored, in the HALES plant. It then passes through a series of processes to vitrify it into a glass-like solid, suitable for long term storage in robust, stainless steel containers in the vitrified product store. Other LLW and ILW are treated in a number of conditioning and abatement plants, to reduce their activity significantly before discharge to sea. 2) **SIXEP:** removes fission products from liquid effluents arising from the spent fuel storage ponds and handling facilities in the Magnox (FHP).

Spent nuclear fuel reprocessing sector - Sellafield	
	3) EARP: reduces levels of plutonium and other actinides, and Tc-99, in intermediate level liquid wastes from THORP and Magnox reprocessing. **4) Solvent Treatment Plant:** destroys solvents used in extraction processes in THORP and Magnox reprocessing, producing an aqueous residue containing the bulk of the radioactivity, which is then sent to EARP. **5) Salt Evaporation Plant:** conditions and concentrates aqueous liquid wastes from Magnox reprocessing prior to treatment in EARP. Processes some arisings from THORP. **6) Segregated Effluent Treatment Plant:** treats low risk and low activity effluents (i.e. those that are not directed to either EARP or SIXEP).
Aerial discharges	
Source of discharges	Ventilation air from process plants during operations associated with the receipt, storage, reprocessing and management of spent nuclear fuels. Ventilation air from decommissioning projects.
Radionuclides reported under RSA93 in RIFE-12	Alpha, beta, tritium, C-14, krypton-85 (Kr-85), Sr-90, Ru-106, antimony-125 (Sb-125), iodine-129, iodine-131, caesium-137, plutonium alpha, Pu-241, Am-241 & Cu-242.
Abatement technology currently used by site operator	**1) HEPA filters** are used as particles are the main source of activity in most of the air streams. **2) Wet scrubbers** are used on streams where significant volatile activity is present. **3) Other equipment** used includes electrostatic precipitators, packed beds, chemical clean-up systems, condensers and pre-heaters (to prevent condensation in the filters).
Dose to critical group (operational and decommissioning)	Current and historical discharges: 0.24 mSv/yr (The major contribution is from historic liquid discharges, particularly plutonium and americium sediments in the Irish Sea – see paragraph 5.3.4)
New abatement technologies to be used by site operator	**Local Effluent Treatment Plant:** an ion-exchange abatement plant for pond aqueous wastes from the pile fuel storage pond. **Separation Area Ventilation Stack:** a new high stack for ventilation of effluents from the Sellafield separation area, to provide additional abatement and reduce future impacts from aerial discharges; completion expected in 2011.

Spent nuclear fuel reprocessing sector - Sellafield	
Other abatement technologies considered by site operator	Research and development directed at improving environmental performance is an ongoing activity, for instance: 1) work is being carried out to help ensure continued SIXEP operations and to improve its capability, hence allowing SIXEP to treat greater amounts of liquors; 2) the sources of Sr-90 and Sb-125 in aqueous discharges from SIXEP are being investigated in order to reduce further the activity of discharges from the plant; and 3) work is continuing through involvement with other national and international companies, conferences and other information links to ensure the use of best practice in current and future operations.
Other comments	**Legacy wastes:** A number of ponds and silos used to store fuel prior to reprocessing and to hold the separated fuel cladding contain 'legacy' wastes that have accumulated over a period of around 50 years. Whilst these wastes are safely managed, they cannot continue to be retained indefinitely in their current facilities. Therefore, Sellafield Ltd is developing new facilities to retrieve and condition the legacy wastes for long-term storage and eventual disposal, ensuring that such facilities and operations represent BAT. However, it is anticipated that the new facilities will inevitably produce some liquid and aerial effluents that will require discharge to the environment. **Tc-99:** Discharges of Tc-99 to sea have significantly reduced due to a combination of two major changes to plant operations. Firstly, there was the successful introduction of abatement technology using the chemical tetraphenylphosphonium bromide within EARP to remove Tc-99 from stored MAC. Secondly, since 2003, MAC arisings have been re-routed to the HALES plant for subsequent vitrification. These two operational changes have resulted in an approximately 90% reduction of Tc-99 discharges into the marine environment. **Nuclear materials** – Future discharges are dependent upon future decisions by the UK Government regarding the status of separated uranium and plutonium. The NDA has been undertaking a review of nuclear materials options to inform such government decisions. A report summarising the initial outcome of this review is available on the NDA's website (www.nda.gov.uk).

Spent nuclear fuel reprocessing sector - Sellafield	
Other comments (continued)	**Spent fuel** – Future discharges are also dependent upon decisions yet to be taken on the management of spent fuel that is not currently planned to be reprocessed – for example some of the UK AGR fuel in wet storage at Sellafield and the PWR fuel currently in dry storage at Sizewell B. The NDA has been undertaking a review of nuclear materials options to inform such decisions. A report summarising the initial outcome of this review is available on the NDA's website (www.nda.gov.uk). Major new facilities currently being developed are: **1) Silos Direct Encapsulation Plant:** to encapsulate the waste from the Magnox swarf storage silo, operational post 2010. **2) Box Encapsulation Plant and Product Store:** to encapsulate some of the retrieved waste from the legacy ponds and store both untreated waste from the pile fuel cladding storage silo and treated waste from the remaining legacy ponds and silos; active commissioning 2015. **3) Sludge Packaging Plant:** to provide storage for sludge from pond retrieval operations and conversion into a directly disposable product, active commissioning expected post 2010.
2002 Strategy commitments	1) Tc-99 discharges to be reduced from close to 90 TBq/year to below 10 TBq/year by no later than end of 2006, and to less than 1 TBq/year by 2020. Discharges fell to below 10 TBq/year in 2005 due to introduction of new abatement technology and re-routing of MAC arisings to the HALES plant for vitrification. Discharges are on course to reduce below 1 TBq/year by 2016. 2) Reprocessing of spent Magnox fuel to cease by around 2012. As mentioned in Chapter 5, this target is not expected to be met, due to technical problems with the Magnox reprocessing plant and with evaporative capacity at Sellafield. The completion of Magnox reprocessing is now likely to take place in, 2016 or later. 3) By 2020 total beta liquid discharges from reprocessing (excluding tritium) to be reduced from 165 TBq/year to around 50 TBq/year. This target is expected to be met.

Spent nuclear fuel reprocessing sector - Sellafield	
	4) By 2020 total alpha liquid discharges from reprocessing to be reduced from 0.31 TBq/year to about 0.2 TBq/Year. This target is expected to be met.
Discharge projections	Spent nuclear fuel reprocessing sector – see Figures 9.1 to 9.7.

9.4 Sector discharge projections

Discharges projections - Spent nuclear fuel reprocessing sector	
Discharge Projections	The projected liquid and aerial discharge profiles to 2030 for the spent nuclear fuel reprocessing sector are at Figures 9.1 to 9.7 below. Uncertainties associated with these projections are discussed at Chapter 6. The predicted discharges for Sellafield do not include effluents resulting from the very last stage of preparing plants for recycle or disposal (i.e. during the final phase of decommissioning), or future radioactivity associated with groundwater and land remediation discharges. There are several reasons for the apparently high aerial discharge predictions from the Sellafield site. The model used to generate the aerial predictions is based primarily on the dataset which was generated for the review of Sellafield discharges authorisations, which was completed in 2004, in line with Environment Agency requirements. Much of the data generated for this review was produced to assist the setting of appropriate discharge limits, i.e. discharge figures were higher than would typically be experienced on a day-to-day basis. In setting discharge limits the environmental benefits (hazard and environmental risk reduction) of taking forward reprocessing of Magnox fuel and treatment of old wastes were taken into account. Work is ongoing to refine the predictions of aerial effluent discharges.
Overall comments	Discharges are anticipated to reduce in future, corresponding to current programmes for the completion of reprocessing. Following cessation of reprocessing activities, discharges will be dominated by those resulting from clean-up and decommissioning activities. According to current programmes of work operational discharges from Sellafield from activities within the "reprocessing category" should have reduced to zero by 2020. Further information on activities at Sellafield and the strategic management of wastes, including discharges, can be found on the Sellafield Ltd website at http://www.sellafieldsites.com/page/media-centre/publications/project-plans--profiles.

Discharges projections - Spent nuclear fuel reprocessing sector	
Strategy expected outcomes	The targets set out below are based on current assumptions that THORP reprocessing operations will cease in 2015 and Magnox reprocessing will end in, 2016 or later. By 2020: • total-alpha (liquid) discharges will be reduced from around 0.25 TBq/yr to below 0.1 TBq/yr. • total-beta (liquid) discharges will be reduced from around 40 TBq/yr to below 20 TBq/yr. • H-3 (liquid) discharges will be reduced from around 1000 TBq/yr to below 100 TBq/yr. • Tc-99 (liquid) discharges will be reduced from around 6 TBq/yr to below 1 TBq/yr. By 2030: • total-alpha (liquid) discharges will be reduced to below 0.05 TBq/yr. • total-beta (liquid) discharges will be reduced to below 10 TBq/yr. • H-3 (liquid) discharges will be reduced to below 10 TBq/yr. • Tc-99 (liquid) discharges will be reduced to below 0.1 TBq/yr.

Figure 9.1: Total alpha discharges from spent nuclear fuel reprocessing sector (liquid)

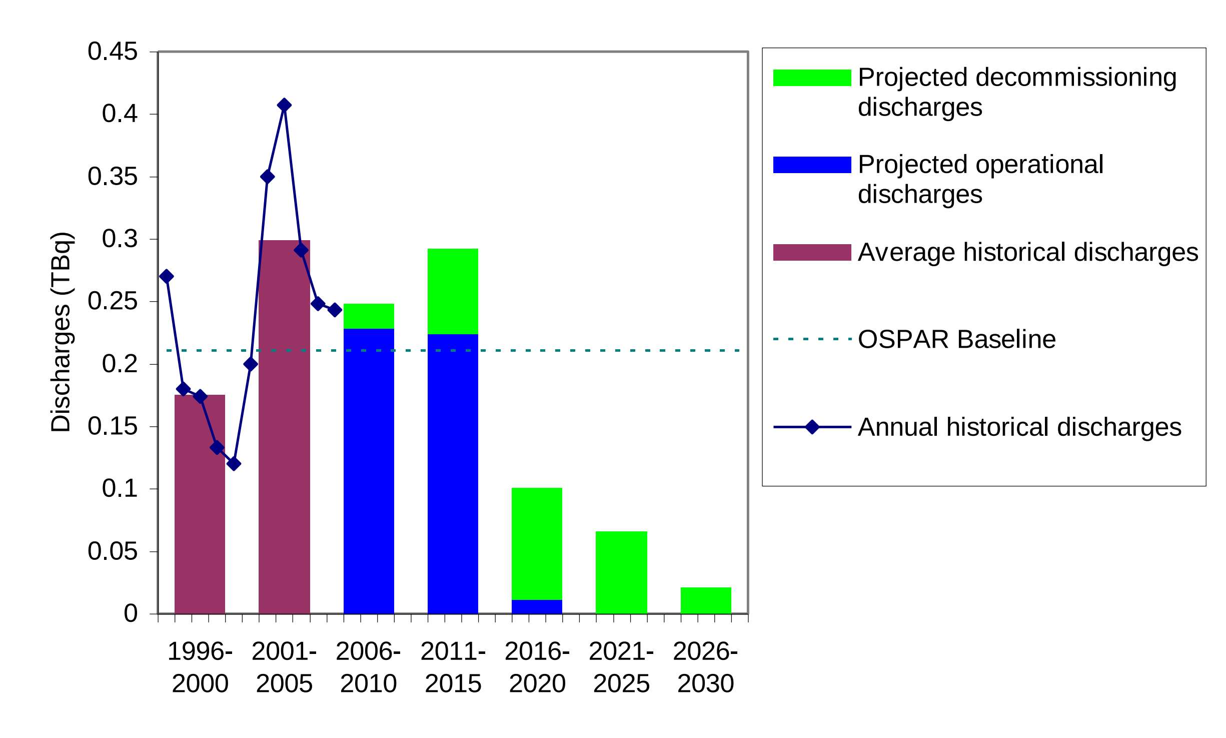


Figure 9.2: Total beta discharges from spent nuclear fuel reprocessing sector (liquid)

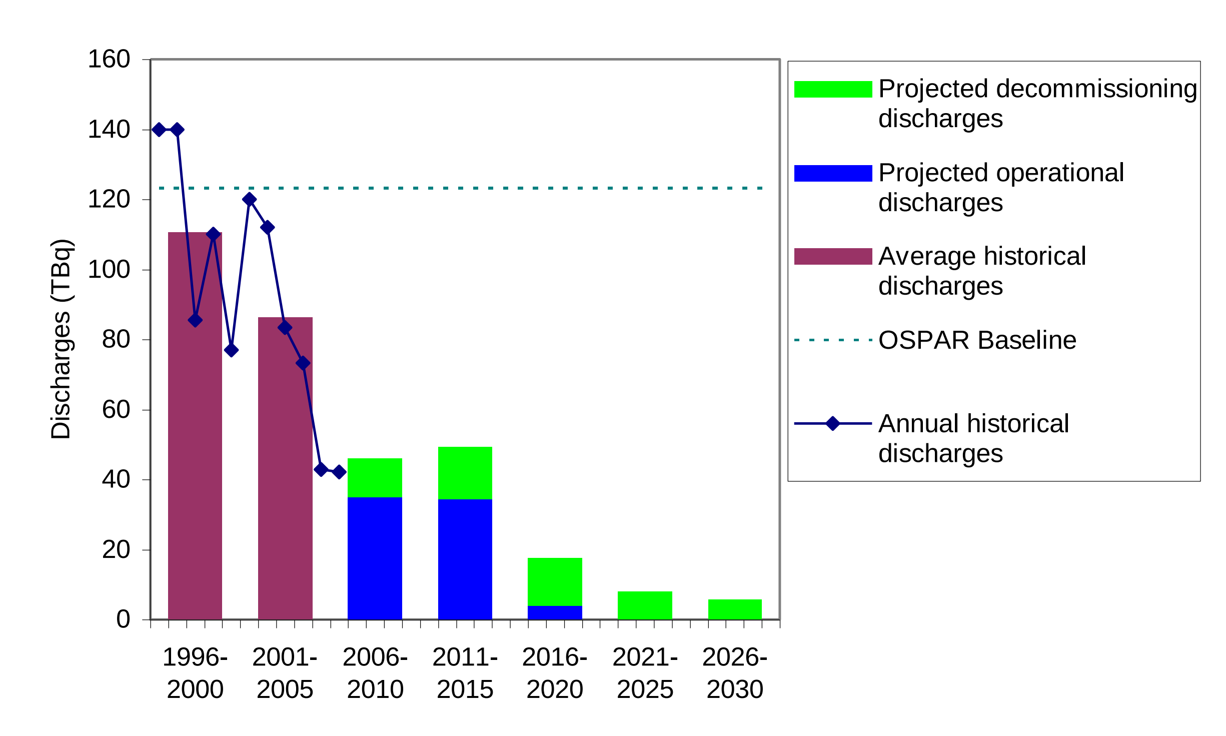


Figure 9.3: H-3 discharges from spent nuclear fuel reprocessing sector (liquid)

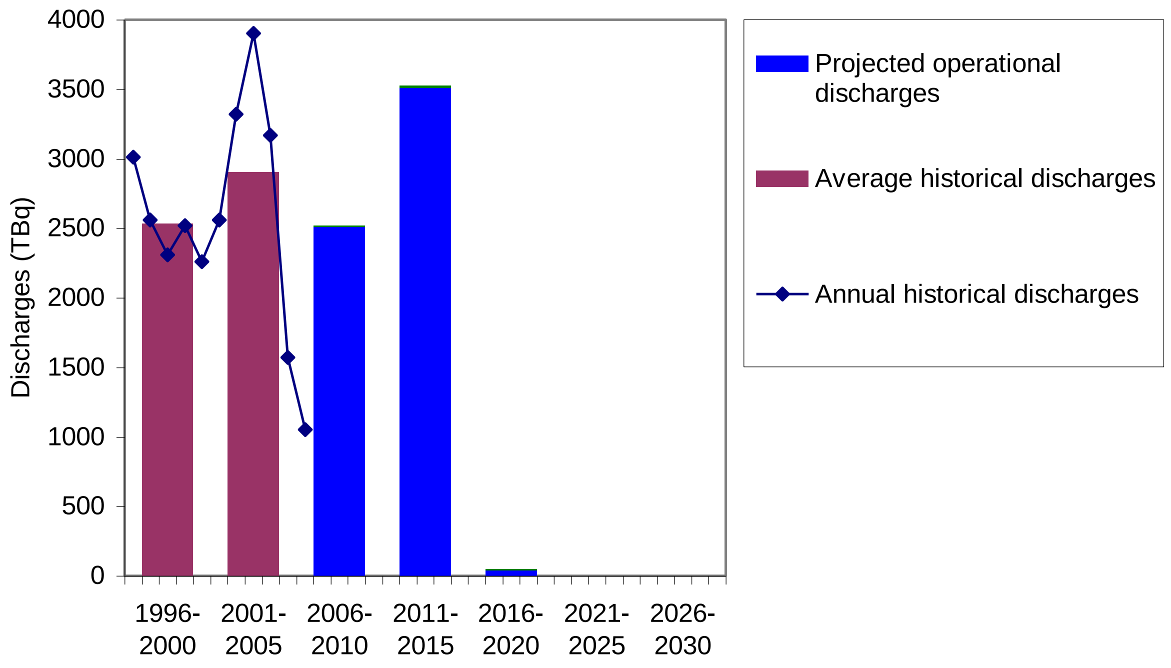


Figure 9.4: Tc-99 discharges from spent nuclear fuel reprocessing sector (liquid)

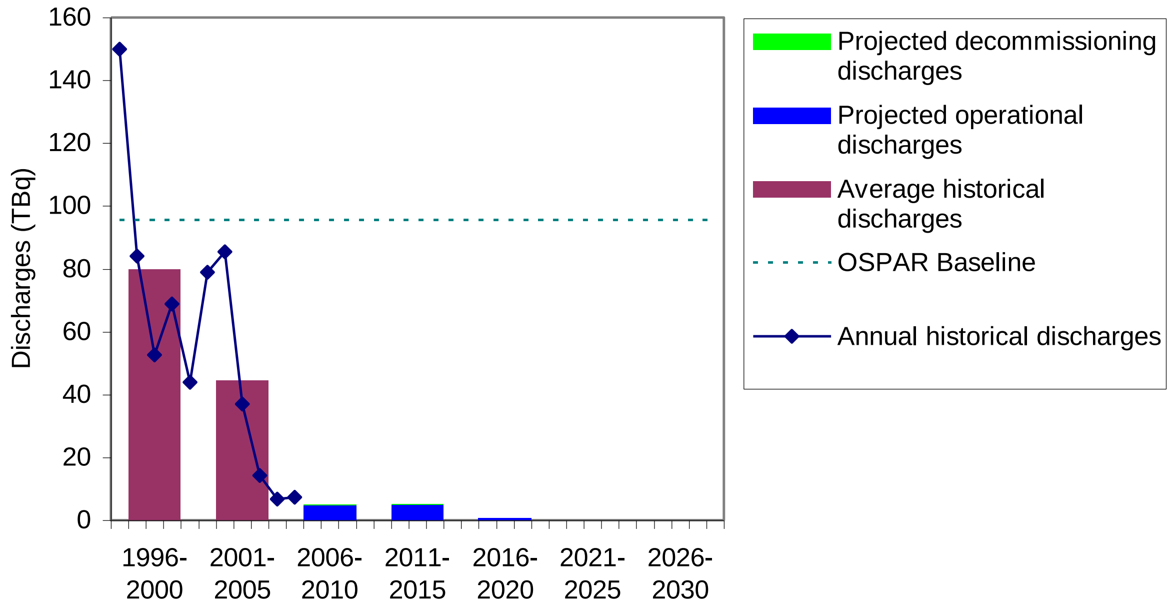


Figure 9.5: Total alpha discharges from spent nuclear fuel reprocessing sector (aerial)

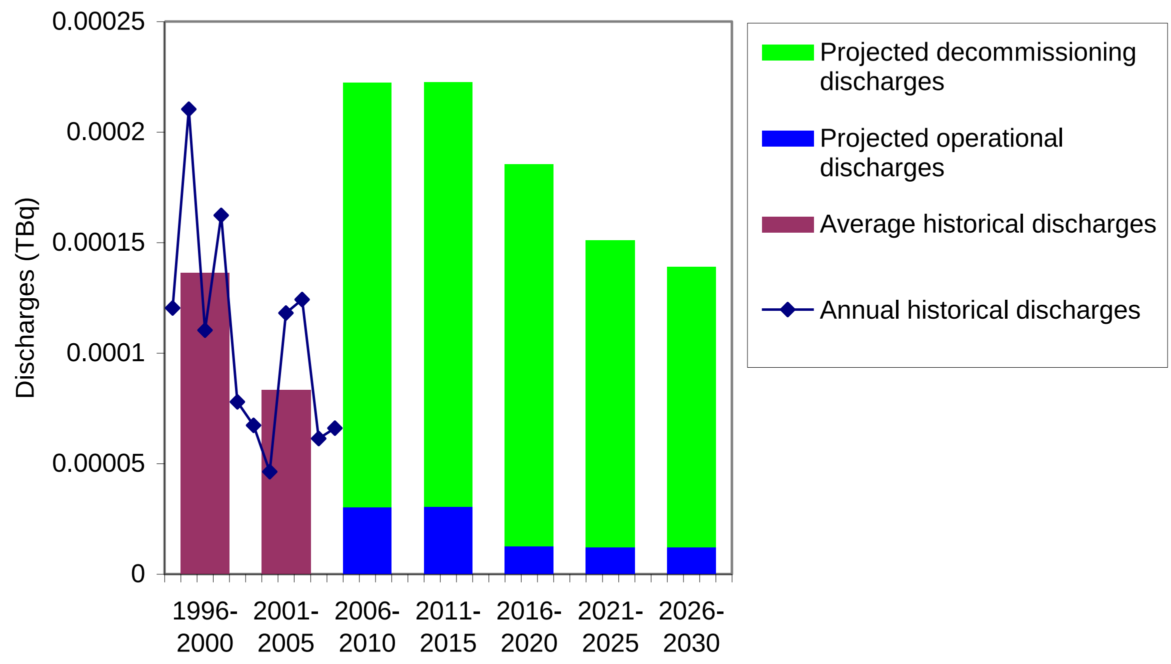


Figure 9.6: Total beta discharges from spent nuclear fuel reprocessing sector (aerial)

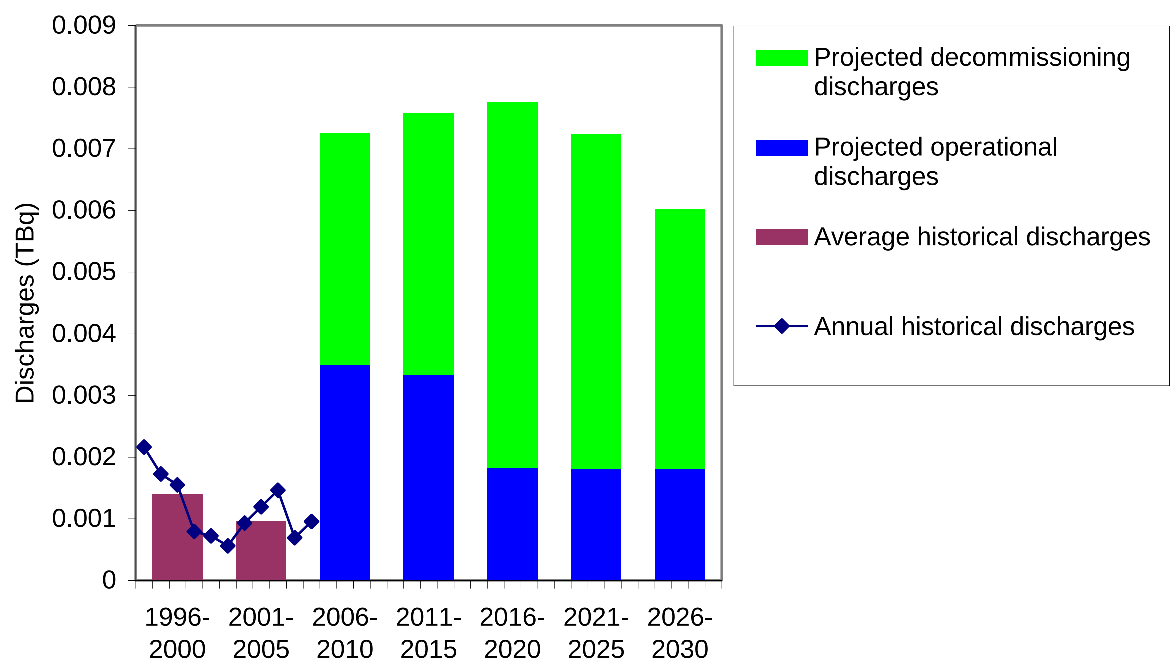
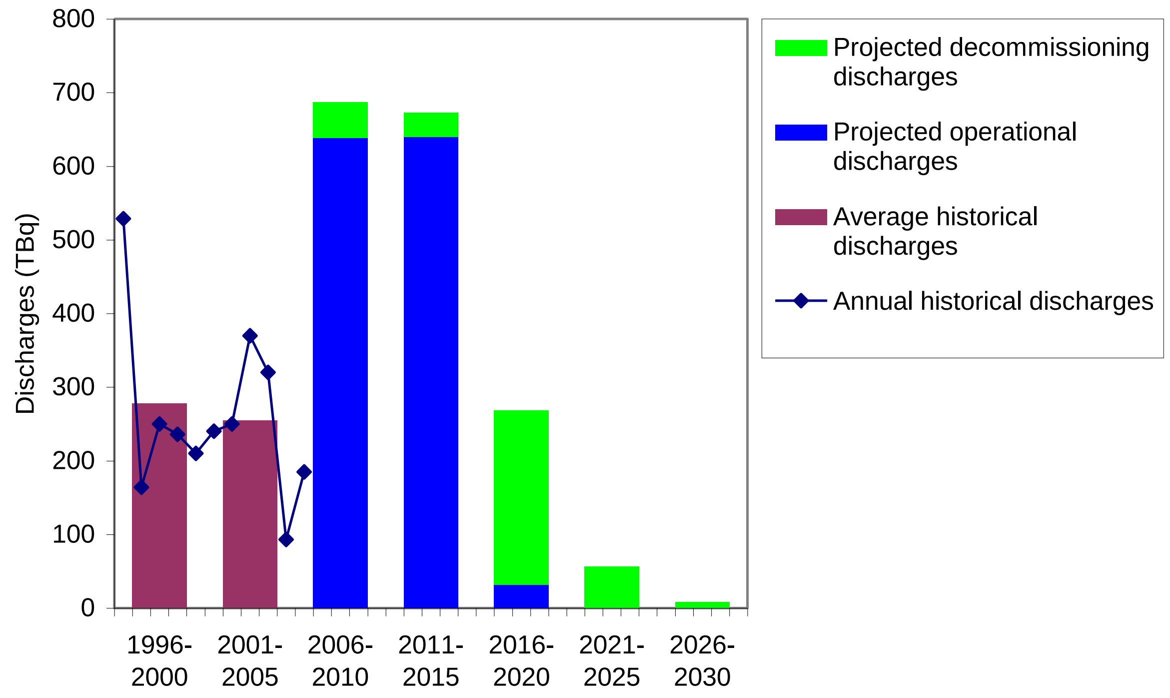


Figure 9.7: H-3 discharges from spent nuclear fuel reprocessing sector (aerial)



Chapter 10 - Nuclear Research Facilities

10.1 The majority of the former UKAEA nuclear research establishments are being decommissioned, at three licensed nuclear sites - Dounreay, Harwell and Winfrith. Their locations are shown on Map 1. The reactors located on these sites have since closed down and are at various stages of decommissioning. Ownership of the sites (with the exception of Harwell) was transferred to the NDA in April 2005. In April 2008, licensee responsibility for the Windscale site, also being decommissioned, was transferred from UKAEA to Sellafield Ltd.

10.2 Other nuclear research facilities, still in operation, include the nuclear fusion research centre at Culham (owned and operated by UKAEA), facilities operated by National Nuclear Laboratory (NNL) at the British Technology Centre (BTC) at Sellafield and two smaller facilities (the post irradiation examination facility at Windscale and the Springfields Technology Centre (STC)). Profiles of these facilities are found on the following pages with the exception of the STC which is described in chapter 7.

10.3 The National Nuclear Laboratory (NNL) is a principal supplier of R&D and technology services to the UK nuclear market. It operates facilities handling radioactive materials based on the Sellafield, Windscale and Springfields sites and supports both ongoing operations and decommissioning activities across the UK from its active facilities.

10.4 A number of companies are tenants at Harwell and Winfrith and hold separate authorisations to discharge radioactivity. Only one of these companies (Scientifics Ltd) undertakes operations which relate to nuclear research. The other tenants are addressed in this strategy under the appropriate nuclear or non-nuclear sectors.

10.5 Over the last twenty to thirty years, radioactive discharges from the research sector have reduced substantially, as research and prototype reactors have ceased operation, and as abatement has been applied to the remaining discharges.

10.6 Over the next 20 years, UKAEA's main activities leading to discharges of radioactivity into the environment from its licensed sites will be associated primarily with the decommissioning of redundant nuclear facilities. Future discharges will, therefore, depend on the decommissioning programme for each site, which is itself dependent on NDA funding for these sites.

10.7 As indicated at Chapter 8, in order to deliver real progress in dealing with the higher hazard facilities, principally at Sellafield and Dounreay, NDA funding will need to be reprioritised from other areas. It is, therefore possible that, as a result of such reprioritisation, some plants at Harwell and Winfrith will undergo a period of care and maintenance until further funding can be provided for the decommissioning programmes on these sites. This will affect the timing of discharges associated with specific decommissioning projects which may be subject to further changes. However, any such voluntary delays to decommissioning are subject to regulation by the NII and can only happen with their approval.

Research Sector – Dounreay	
 Image supplied courtesy of UKAEA	
Location	Caithness, Scotland
Ownership	Operated by Dounreay Site Restoration Ltd., and owned by NDA. As part of UKAEA restructuring Dounreay Site Restoration Ltd. assumed responsibility for the operation of the site from 1 April 2008.
History	Research and development of fast reactor technology (including reprocessing) of fast reactor fuel. 1994 - last of the three reactors closed 1996 - reprocessing plant closed
Current use	Decommissioning of research and prototype reactors, reprocessing plant and auxiliary facilities. Operation and further construction of waste treatment and storage facilities.
Decommissioning plans	An overview of the decommissioning plans for the Dounreay site is available on the NDA website www.nda.gov.uk.
Liquid discharges	
Main source of discharges	Liquid alpha and beta discharges are mainly associated with the decommissioning of the reprocessing plant and fuel cycle areas. Liquid H-3 discharges are mainly from the dissolution of alkali metals (sodium and potassium) formerly used as fast reactor coolant.
Radionuclides reported under RSA93 in RIFE-13	Prototype Fast Reactor (PFR) liquid metal disposal plant: Alpha, beta, H-3, sodium-22, Cs-137. Other facilities: Alpha, beta, H-3, Sr-90, Cs-137.
Abatement technology currently used by site operator	Cs-137 discharge reduction is being achieved using recently constructed ion exchange plants.
Aerial discharges	
Source of discharges	Alpha discharges: ventilation of redundant facilities

Research Sector – Dounreay		
	contaminated with plutonium and enriched uranium. Beta discharges: ventilation of redundant facilities contaminated with fission products, release of Kr-85 from spent fuel. H-3 discharges: dissolution of alkali metals (fast reactor coolants) as part of decommissioning and clean up.	
Radionuclides reported under RSA93 in RIFE-13	Fuel cycle area: Alpha, beta, H-3, kr-85, Sr-90, Ru-106, I-129, I-131, Cs-134, Cs-137, Ce-144, Pu-241, Cm-242, Cm-244. Fast reactor & PFR: Alpha, beta, H-3, Kr-85. PFR minor sources & West minor sources: Alpha, beta, H-3. East minor sources: Alpha, beta, Kr-85.	
Abatement technology currently used by site operator	A variety of abatement at source techniques is used to reduce the generation of airborne particles. In addition HEPA filtration is used to abate aerial discharges prior to discharge.	
Dose to critical group	2007 – 0.047 mSv/yr (highest dose to local terrestrial food consumers, including contribution from weapons test fall out)	2030 (prospective dose calculated by site operator) – <0.01 mSv/yr
Other abatement technologies considered by site operator	1) Further tritium abatement is not currently considered BPM as the high salt content and the presence of gamma emitting radionuclides makes these liquid effluents unsuitable for treatment with currently available abatement techniques - e.g. the tritium treatment techniques at Culham, which deal with tritium in otherwise clean air or water. 2) Evaporation and solidification – currently considered neither practical nor cost effective. Estimated cost £400 million over the next 50 years.	
Other site users	HM Naval Base Vulcan Naval Reactor Test Establishment – operating a prototype naval nuclear propulsion reactor and associated facilities (discharges are included in defence sector data).	
Other comments	As new decommissioning and waste treatment projects are planned, abatement of potential discharges at source is used where practicable, to reduce the requirement to abate in the discharge route.	
Discharge projections	Discharges will continue to decline as plant is decommissioned and as wastes are converted from mobile to immobile forms by techniques such as cementation, although such decommissioning activities may result in some short term increases in discharges. Research sector projections – see Figures 10.1 to 10.6.	

Research Sector – Harwell

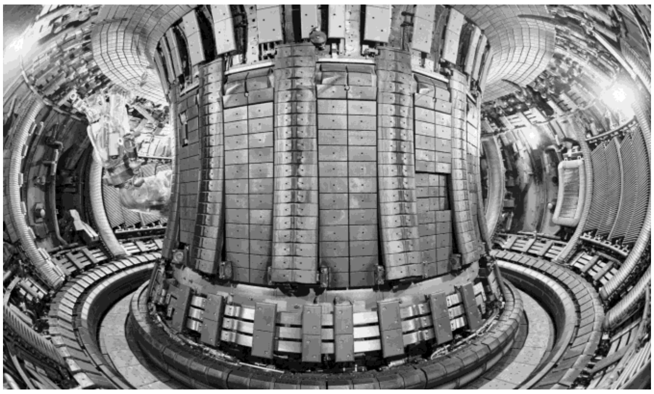
Image supplied courtesy of UKAEA

Location	Oxfordshire
Ownership	Owned by UKAEA, with the licensed site leased to the NDA. As part of UKAEA restructuring, Research Sites Restoration Ltd became responsible for the operation of the licensed site in 2008.
History	Several research reactors, the most significant of which were the Harwell materials testing reactors. The last of these closed in 1990.
Current use	Decommissioning of research reactors, a large radiochemical facility and auxiliary facilities. The management of low and intermediate level wastes arising from these decommissioning activities.
Decommissioning Plans	An overview of the current decommissioning plans for the Harwell site is available on the NDA website www.nda.gov.uk.
Liquid discharges	
Main source of discharges	Alpha & beta discharges: decommissioning of solid waste treatment complex. Significant reductions in liquid discharges are anticipated as a result of decommissioning and eventually discharges will cease when the site end state is reached around 2025.
Radionuclides reported under RSA93 in RIFE-13	Pipeline: Alpha, beta, H-3, Co-60, Cs-137. Lydebank Brook: Alpha, Beta, H-3.
Abatement technology currently used by site operator	1) The liquid effluent treatment plant applies a range of physical (settlement and filtration) and chemical (precipitation) treatments dependent on the effluents received, to remove activity prior to discharge. 2) The main emphasis is to reduce effluent volumes in the active stream down to the level where cementation of process wastes becomes feasible. Evaporation is being considered if volumes can be reduced sufficiently.

Research Sector – Harwell		
Aerial discharges		
Source of discharges	Alpha & beta discharges: the decommissioning of radiochemical and ancillary facilities. H-3 discharges: the decommissioning of the materials test reactors.	
Radionuclides reported under RSA93 in RIFE-13	Alpha, beta, H-3, Kr-85, Rn-220, 222 (radon-220, 222), iodines, other radionuclides.	
Abatement technology currently used by site operator	HEPA filters are used to abate alpha and beta particulate discharges; delayed trapping techniques are used to reduce Rn-220 discharges from stored wastes. A variety of other abatement at source techniques is used to reduce the generation of airborne particles.	
Dose to critical group	2007 – 0.006 mSv/yr (highest dose to anglers)	2030 (prospective dose calculated by site operator) – <0.005 mSv/yr
Other abatement technologies considered by site operator	The capture of tritium gases from reactors and its conversion to liquid or solid form has been considered in the past but would not be cost effective. Some tritium legacy sources may be encapsulated.	
Other site users	Scientifics Ltd – analytical laboratory which has its own authorisation for disposal of very small quantities of radioactive waste resulting from analysis of samples containing radioactive material.	
Other comments	UKAEA provides a waste disposal service to tenants on the site and is currently receiving surplus sources from across the UK for processing and disposal while other facilities at Sellafield are unavailable.	
Discharge projections	Discharges will continue to decline as plant is decommissioned and as mobile wastes are immobilised – e.g. by cementation, although such decommissioning activities may result in some short term increases in discharges. Research sector projections – see Figures 10.1 to 10.6.	

Research Sector – Winfrith	
 Image supplied courtesy of UKAEA	
Location	Dorset
Ownership	Operated by Research Site Restoration Ltd. and owned by NDA. As part of UKAEA restructuring, Research Sites Restoration Ltd became responsible for the operation of the site in 2008.
History	Research to support reactor development, fuel manufacture and waste treatment and storage, including operation of the Steam Generating Heavy Water Reactor (SGHWR) until 1990.
Current use	Decommissioning of remaining reactors. Future storage of intermediate level waste prior to transfer to off-site intermediate storage or disposal to a national repository.
Decommissioning Plans	An overview of the current decommissioning plans for the Winfrith site is available on the NDA website www.nda.gov.uk.
Liquid discharges	
Main source of discharges	Alpha & beta discharges: decommissioning operations and the treatment of legacy wastes.
Radionuclides reported under RSA93 in RIFE-13	Inner pipeline: Alpha, H-3, Cs-137, other radionuclides. Outer pipeline: Alpha, H-3, other radionuclides. River Frome: H-3.
Abatement technology currently used by site operator	The active liquid effluent system which collects liquid waste for discharge to the sea is expected to close after decommissioning of the SGHWR primary circuit is complete around 2017. Work will be undertaken to reduce effluent volumes.
Aerial discharges	
Source of discharges	Alpha discharges: decommissioning operations. Beta discharges: decommissioning operations and the treatment of legacy wastes.

Research Sector – Winfrith		
Radionuclides reported under RSA93 in RIFE-13	Alpha, H-3, C-14, other.	
Abatement technology currently used by site operator	HEPA filters are used where significant particulate levels are expected.	
Dose to critical group	2007 – <0.005 mSv/yr	2030 (prospective dose calculated by site operator) – <0.005 mSv/yr
Other abatement technologies considered by site operator	1) A recent study to consider the optimum approach for managing radioactive wastes on the site concluded that the current disposal routes represent BPEO. 2) Tritium abatement, using a dehumidifier or scrubber is currently being investigated for the decommissioning of the primary containment at SGHWR.	
Other site users	Three tenants on the site discharge radioactivity, but are not involved in the nuclear research sector. Discharges associated with these operators are included within the scope of chapters 13 and 14 – Nuvia Ltd (oil and gas sector), AMEC NNC (waste sector) and WMTL (waste sector).	
Discharge projections	Discharges will decline as plant is decommissioned and legacy wastes are treated, although such decommissioning activities may result in some short term increases in discharges. Research sector projections – see Figures 10.1 to 10.6.	

<table>
<tr><th colspan="3">Research Sector – Culham</th></tr>
<tr><td colspan="3">
Image supplied courtesy of UKAEA</td></tr>
<tr><td>Location</td><td colspan="2">Oxfordshire</td></tr>
<tr><td>Ownership</td><td colspan="2">Owned and operated by UKAEA. UKAEA will be responsible for decommissioning the site, with the exception of the Joint European Torus (JET) experimental fusion facility. Once JET ceases operations responsibility for decommissioning will fall to NDA, subject to Government approval.</td></tr>
<tr><td>Current use</td><td colspan="2">Since 1978, site of JET which carries out nuclear fusion energy experiments using tritium.</td></tr>
<tr><td>Decommissioning Plans</td><td colspan="2">The earliest assumed date for the end of JET operations (for the purpose of planning decommissioning) is the end of 2010. Further extending this operational period is under active consideration and is considered likely.</td></tr>
<tr><td colspan="3">Liquid and aerial discharges</td></tr>
<tr><td>Main source of discharges</td><td colspan="2">JET</td></tr>
<tr><td>Radionuclides reported under RSA93</td><td colspan="2">H-3, other beta/gamma particulate</td></tr>
<tr><td>Abatement technology currently used by site operator</td><td colspan="2">Purpose built state-of-the-art plant for handling and treating tritium and compounds in gaseous form. Reduces tritium discharges routed through it by 95%.</td></tr>
<tr><td>Dose to critical group</td><td>2007 (calculated by site operator) – <0.0001 mSv/yr</td><td>2030 (prospective dose calculated by site operator) – <0.0001 mSv/yr</td></tr>
<tr><td>Other abatement technologies considered by site operator</td><td colspan="2">Air scrubbing columns are being evaluated for possible application.</td></tr>
</table>

Research Sector – Culham	
Other comments	The experimental nature of this facility means that the content of the programme and hence the quantities of discharged radioactivity are not easily predictable in the medium to long term (approx 1TBq/yr liquid & 0.01TBq/yr aerial). The earliest decommissioning start date of facility is 2010, but this is dependent on future funding.
Discharge projections	Neither discharges nor dose are expected to increase significantly. Research sector projections – see Figures 10.1 to 10.6.

Research Sector – Windscale	
 Image supplied courtesy of the NDA	
Location	Sellafield, Cumbria
Ownership	Operated by Sellafield Ltd and owned by the NDA, with UKAEA providing staff through a Resource Enhancement Contract. Authorised radioactive discharges are now managed together with those of the main Sellafield site. The National Nuclear Laboratory undertakes a range of post irradiation examination and material processing as a tenant in shielded facilities at Windscale.
History	Production of plutonium and other radioactive isotopes for the atomic weapons programme by the Windscale pile reactors (1950-1957), which ceased operation after the Windscale fire in 1957. Later (1963-1981) the site undertook research into the development of the advanced-gas cooled reactor design including the operation of the prototype Windscale Advanced Gas Reactor (WAGR). Operation of a shielded facility for 'post-irradiation examination' of spent fuel and for various waste management activities.
Current use	Decommissioning of reactors and associated facilities. Post-irradiation examination of spent nuclear fuel. Management of gamma and beta-gamma active wastes. Facility for the receipt and processing of surplus sources from across the UK which are sent to the miscellaneous beta gamma waste store at Sellafield for safe long term storage pending disposal.
Decommissioning plans	An overview of the current decommissioning plans for the Windscale site is available on the NDA website www.nda.gov.uk.

Research Sector – Windscale		
Liquid discharges		
Main source of discharges	Alpha & beta discharges: post-irradiation examination and waste treatment	
Radionuclides reported under RSA93 in RIFE-13	Reported as part of the Sellafield site discharges (chapter 9)	
Abatement technology currently used by site operator	Filtration to remove solids and waste characterisation is carried out prior to transfer via tanker to the adjoining Sellafield site, for discharge through the Sellafield effluent treatment and abatement plants.	
Aerial discharges		
Source of discharges	Alpha and beta discharges: post-irradiation examination and waste treatment, radioactive material remaining in Pile-1 pending its decommissioning, decommissioning of Pile-1 and the WAGR. H-3 discharges: spent fuel and isotope cartridges	
Radionuclides reported under RSA93 in RIFE-13	Reported as part of the Sellafield site discharges (Chapter 9).	
Abatement technology currently used by site operator	HEPA filtration is used. A variety of abatement at source techniques is used to reduce the generation of airborne particles.	
Dose to critical group	2007 (calculated by site operator) – <0.01 mSv/yr	2030 (prospective dose calculated by site operator) – <0.01 mSv/yr
Other abatement technologies considered by site operator	Following filtration at Windscale, abatement for liquid discharges takes place in Sellafield site plants - see Sellafield information.	
Discharge projections	It is not possible to quantify the exact discharges transferred to the Sellafield site (although they are very small), therefore discharges from Windscale are included in the discharge profiles for the Sellafield site (reprocessing sector).	

Research Sector – British Technology Centre (BTC)		
 Image supplied courtesy of British Nuclear Group Ltd		
Location	Sellafield, Cumbria	
Ownership	Owned by NDA, part of Sellafield site operated by Sellafield Ltd., Technology Centre is leased and managed by National Nuclear Laboratory (NNL).	
Current use	Nuclear research and development. It is expected to form part of the NNL.	
Liquid and aerial discharges		
Main source of discharges	Support to Magnox and THORP reprocessing plants, decontamination studies, floc & sludge characterisation and cementation trials, decommissioning support, aerial and liquid effluent studies, graphite testing in support of continued reactor operations, materials testing and (Mixed Oxide Fuel) MOX support.	
Radionuclides reported under RSA93 in RIFE-13	Reported as part of the Sellafield site discharges (Chapter 9).	
Abatement technology currently used by NNL	1) Liquid discharges transferred by pipeline or tanker to adjoining Sellafield Ltd site for treatment and discharged through Sellafield effluent treatment plants. 2) HEPA filters are used for aerial discharges.	
Dose to critical group	2007 – <0.01 mSv/yr (calculated by site operator)	2030 – <0.01 mSv/yr (prospective dose calculated by site operator)
Other abatement technologies considered by NNL	Individual experiments are subject to review and abatement techniques applied as required.	

Research Sector – British Technology Centre (BTC)	
Discharge projections	It is not possible to quantify the exact discharges transferred to Sellafield site (although they are very small), therefore discharges from NNL are included in the discharge profiles for the reprocessing sector.

10.8 Sector discharge projections

Discharges projections – research sector	
Discharge Projections	The projected liquid and aerial discharge profiles to 2030 for the research sector are shown in Figures 10.1 to 10.6, below. While some research activities are currently expected to continue throughout the period of this strategy, discharges from the research sector over this period will result almost entirely from the decommissioning of research and prototype reactors and associated reprocessing and ancillary plant. There may be periods when decommissioning discharges will increase from current levels, as specific decommissioning operations are undertaken. The timing of these predicted peaks in discharges will be governed by the timing of these decommissioning activities, which is dependent, amongst other factors on NDA funding and the allocation of funding across NDA sites (see paragraph 10.7).
2009 Strategy expected outcomes	The targets set out below have been based on current decommissioning programmes for Harwell, Winfrith and Dounreay. Changes in decommissioning programmes will have a significant influence on actual decommissioning discharges in the short term. By 2020: • total-alpha (liquid) discharges will have reduced to below 0.025 TBq/yr. • total-beta (liquid) discharges will have reduced to below 0.8 TBq/yr. By 2030: • total-alpha (liquid) discharges will have reduced to below 0.020 TBq/yr. • total-beta (liquid) discharges will have reduced to below 0.2 TBq/yr.

Figure 10.1: Total alpha discharges from nuclear research sector (liquid)

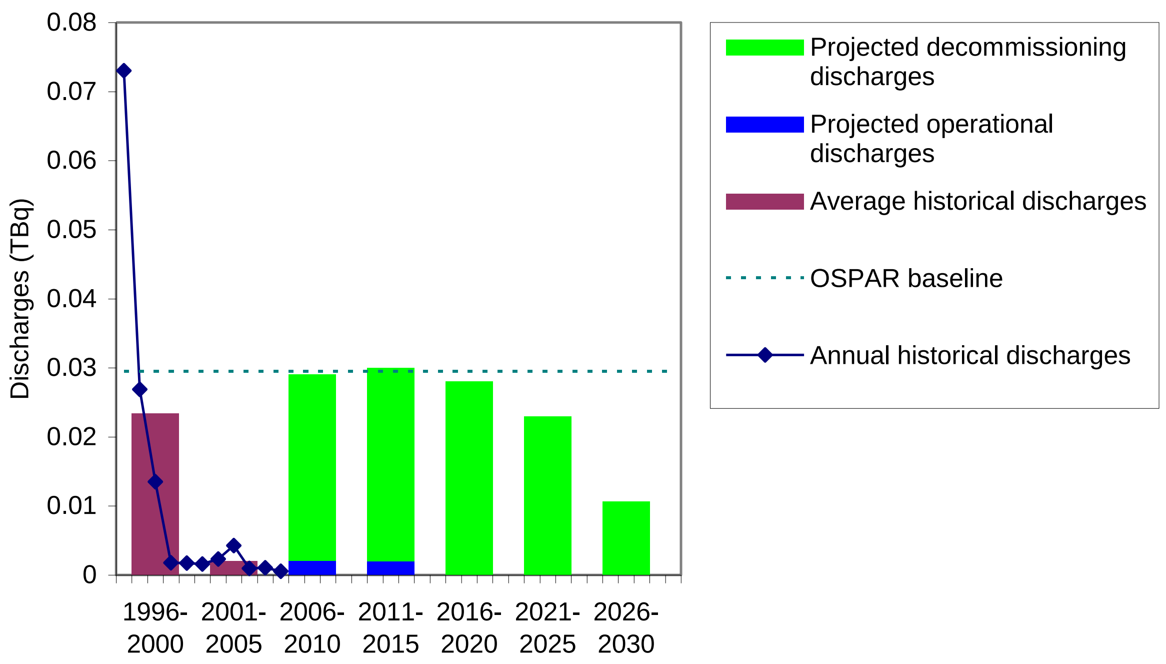


Figure 10.2: Total beta discharges from nuclear research sector (liquid)

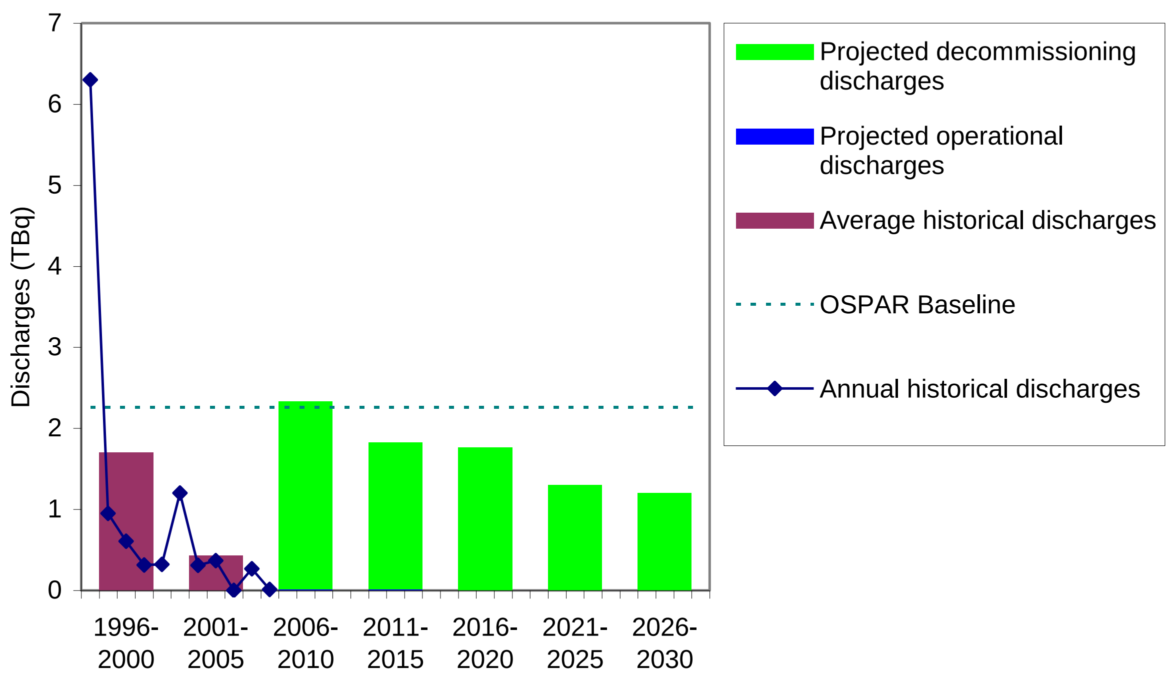


Figure 10.3: H-3 discharges from nuclear research sector (liquid)

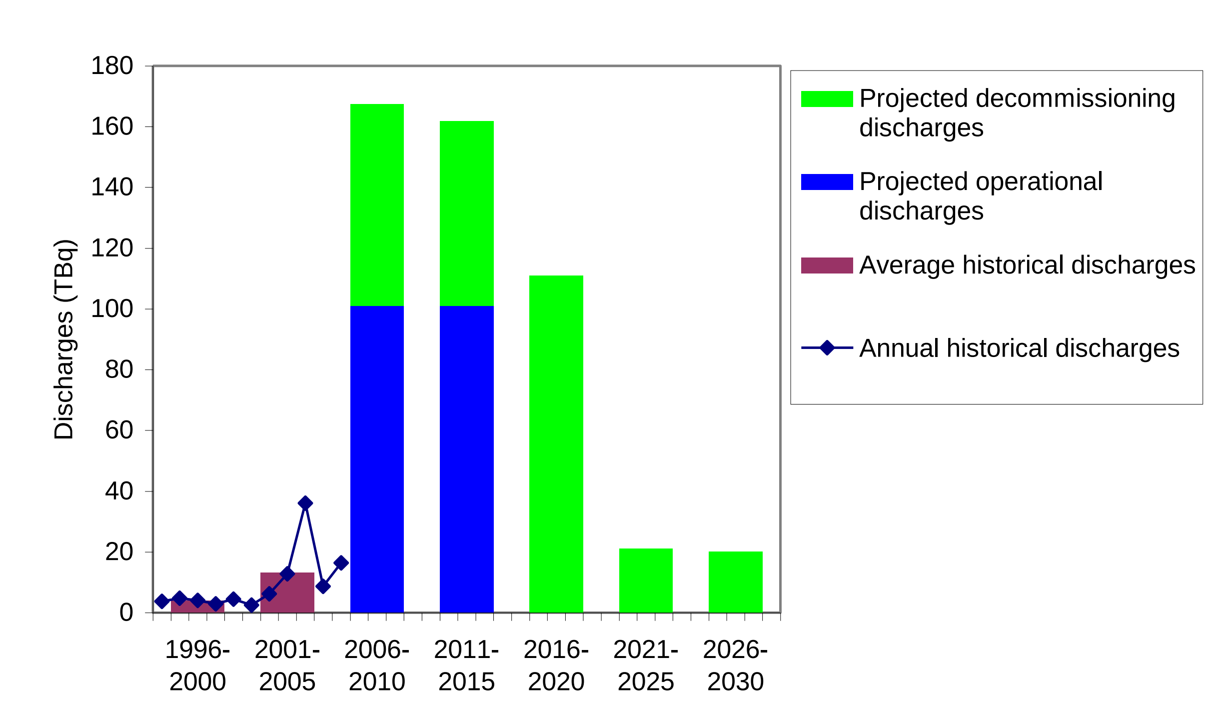


Figure 10.4: Total alpha discharges from nuclear research sector (aerial)

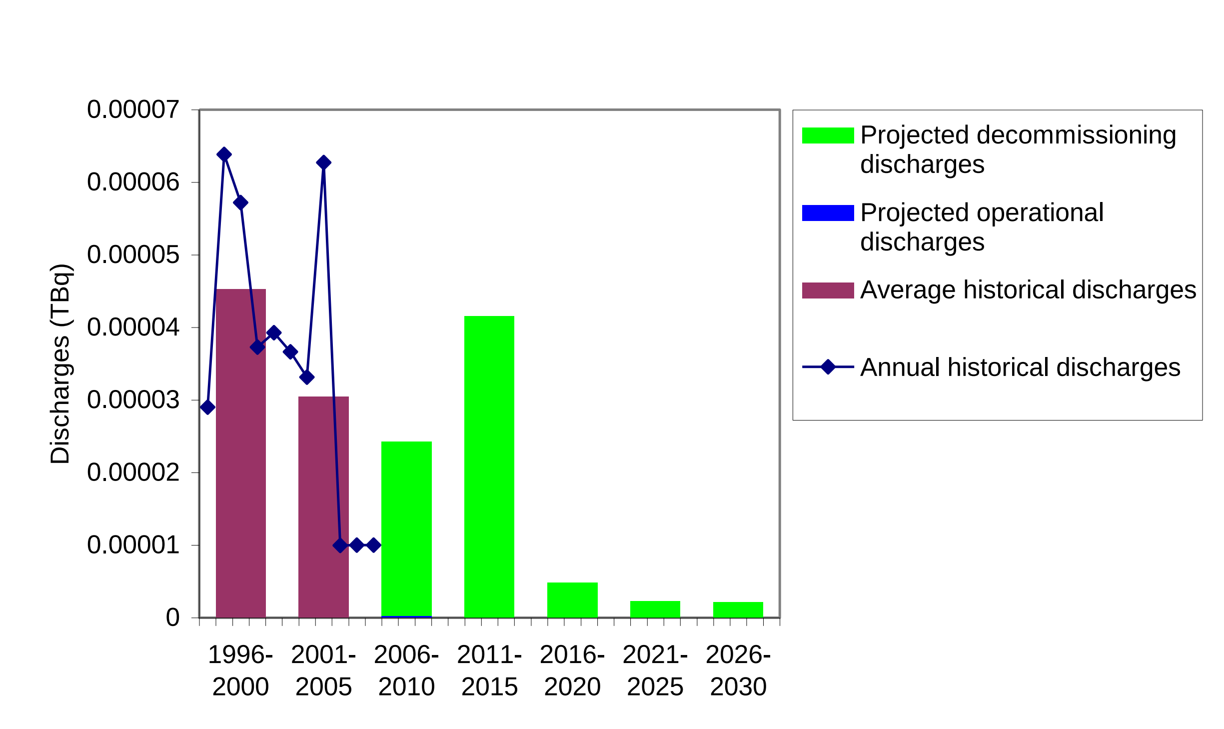


Figure 10.5: Total beta discharges from nuclear research sector (aerial)

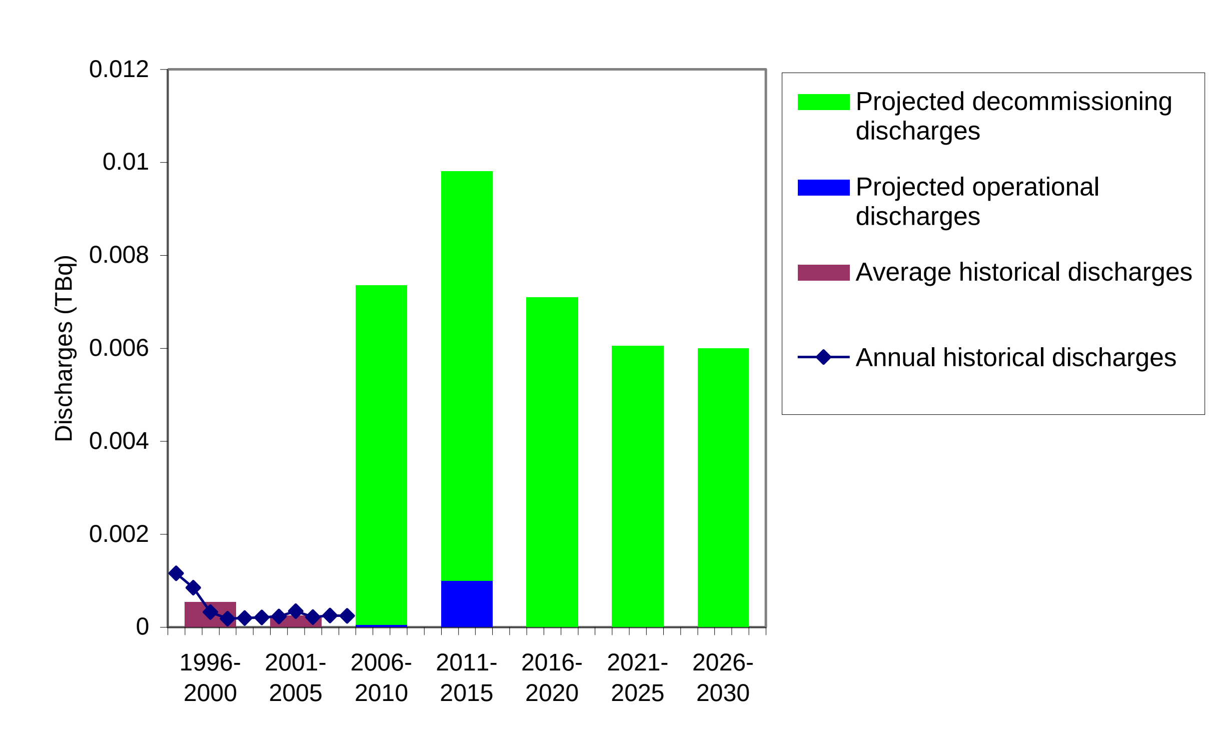
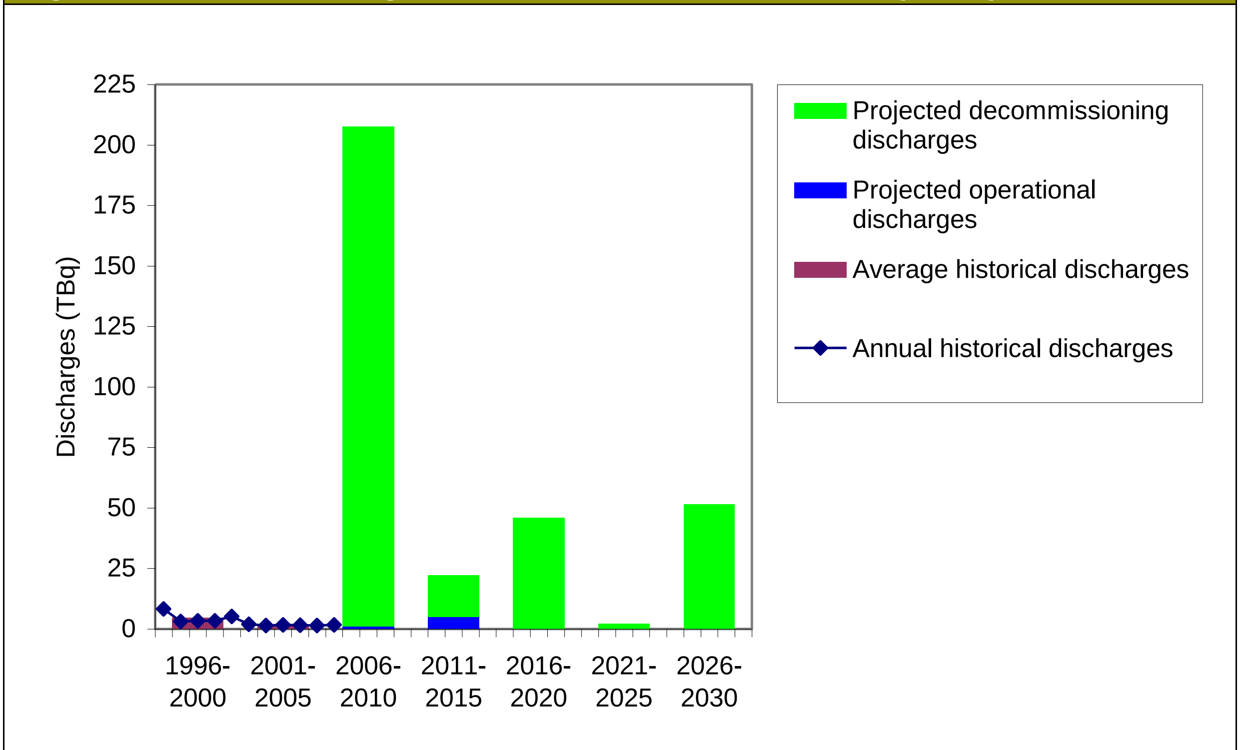


Figure 10.6: H-3 discharges from nuclear research sector (aerial)



Chapter 11 - Defence sector

Defence nuclear programme sector

11.1 The UK Government is committed to maintaining a nuclear deterrent and consequently has a requirement to develop, manufacture and deploy nuclear weapons. To support this commitment, MoD operates four nuclear powered Vanguard Class Trident Ballistic Nuclear Missile Submarines (SSBNs). It also continues to operate nuclear powered Hunter Killer Submarines (SSNs). The new Astute class SSN will shortly enter service and will progressively replace the ageing Swiftsure and Trafalgar Class submarines. All these MoD nuclear programmes result in a contribution of less than 0.1%, in activity terms, to the national radioactive discharges (Figures 4.1 to 4.3).

Nuclear weapons programme

11.2 AWE Aldermaston and Burghfield are today the only establishments supporting the design, development and production of nuclear warheads for the nuclear weapons programme. However, a facility at the Capenhurst site was operated to support the nuclear weapons programme until the late 1980s, after which it was decommissioned and is now a brown field site. The Magnox station at Chapelcross generated electricity for the national grid, but it was built primarily to support the nuclear weapons programme. Production of material to be used for defence purposes ended in 2003 and the facility is currently being decommissioned. Tritium discharge projections for the Chapelcross facility are shown separately in Figures 11.7 and 11.8.

Nuclear submarine propulsion programme

11.3 Propulsion core manufacturing at Rolls-Royce’s Derby factory contributes most of the alpha discharges. However, owing to rigorous accountancy standards and high levels of re-use, recycling and abatement, the magnitude of discharges is small, with correspondingly little potential environmental impact. Particulate emissions to atmosphere from stacks are measured continuously, and activity in liquid effluent discharges to sewer is measured before each tank is sentenced.

11.4 Beta/gamma discharges result mainly from the propulsion programme. The Vanguard Class of SSBN uses the pressurised water reactor variant PWR2 which does not discharge to sea. Two of the SSBNs have been “fuelled for life2 and the remaining two SSBNs will be “fuelled for life” at the next appropriate maintenance period.

11.5 The current classes of SSN use the reactor variant PWR1 which discharge very small quantities of reactant coolant to sea as a necessary part of operation, due to expansion of coolant. All such discharges are strictly controlled, monitored and recorded. The new astute Class of SSN will use the newer variant PWR2 which does not discharge to sea. The Astute Class will be “fuelled for life” from build, which should reduce discharges from dockyards during submarine maintenance as refuelling will not be necessary.

It is intended that by 2025, all PWR1 variant reactors will have been removed from service.

11.6 The maintenance programme for nuclear submarines does not result in regular annual discharges and so the five year annualised average figures given may not relate directly to required annual discharge authorisations.

Defence non-nuclear sector

11.7 Defence non-nuclear discharges arise from five establishments located on four defence sites. The sites are involved in a diverse range of activities. The work includes equipment refurbishment and repair, research, sample analysis and training. The site at Donnington was the subject of a historic decontamination which removed most of the tritium contamination and what remains is below the sampling minimum recordable level. These discharges are, in general, lower than those from the defence nuclear programmes.

Defence sector – Nuclear weapons programme	
 Image supplied courtesy of AWE. Crown copyright/MoD 2008.	
Location	The development, manufacture, maintenance and eventual decommissioning of nuclear warheads is carried out on behalf of the MoD by the AWE at Aldermaston and Burghfield (Map 1).
Overview of discharges	Discharges are divided between legacy waste related activities (e.g. decommissioning of redundant facilities) and ongoing operations. The proportion contributed in future by each aspect (decommissioning and ongoing operations) will depend on Government policy decisions that have yet to be taken about the future of the UK nuclear deterrent. There are no liquid discharges from the Burghfield site. Projected tritium discharges result almost entirely from the weapons programme.
Liquid and aerial discharges (AWE Aldermaston)	
Main source of discharges	The principal remaining liquid discharge is from the Aldermaston site via a sewer to the Silchester Sewage Treatment Works, although the levels of activity discharged have reduced to near background.
Radionuclides reported under RSA93 in RIFE-13	Liquid (Aldermaston) – Alpha, H-3, Pu-241, other radionuclides. Aerial (Aldermaston)– Alpha, H-3, Kr-85, Pu-241, other beta and gamma emitters. Burghfield: H-3, uranium.
Abatement technology currently used by site operator	A new evaporator-based liquid effluent treatment plant was built and commissioned to take over duty from the previous Aldermaston plant and disposal pipeline. The disposal pipeline to the Thames was taken permanently out of use in 2003 and is now partially decommissioned. The new plant discharges virtually pure water as a minor input to the site's trade waste treatment and disposal.

Defence sector – Nuclear weapons programme	
Dose to critical group	<0.005 mSv/yr (2007, calculated by site operator) - most of this is contributed by discharges of tritium to air.
Other abatement technologies considered by site operator	Nearly all abatement is already ‘best practice’, e.g. evaporation to remove all dissolved and suspended activity from liquid effluent, and the use of high efficiency filtration for removal of particulates from airborne discharges. New facilities will be designed to reduce, as far as reasonably practicable, airflow and water use, thus minimising the discharge volumes and therefore the “sums of limit of detection values effect” that currently leads to over-reporting of discharge totals. Improved metrology for measuring discharges, together with improved statistical methodologies for interpreting the measurement data, should eventually lead to more accurate and therefore smaller discharge values.
Other comments	AWE also carries out work in support of the Non-Proliferation Treaty, some of which results in small discharges of very little radiological consequence.
Discharge projections	Defence sector projections – see Figures 11.1 to 11.6. Chapelcross projections – see Figures 11.7 and 11.8.

Defence sector – Nuclear propulsion programme	
 Image supplied courtesy of MoD. Crown Copyright/MOD 2008	
Location	Submarines undergo refit, repair or decommissioning at the Royal Dockyard at Devonport, Plymouth and operational maintenance at the Clyde Naval Base, Faslane, Scotland and at HMNB (Devonport) (Map 1). The submarines are powered by small, pressurised water reactors that use enriched uranium fuel clad with Zircalloy, manufactured by Rolls Royce Marine Power Operations Ltd., in Derby. Refitting work at Rosyth has ended and all future refits will be carried out at Devonport, although some decommissioning work is likely to continue at Rosyth for several years.
Overview of discharges	The main contributor of alpha discharges is from propulsion core manufacturing. Projected beta/gamma discharges result almost entirely from the propulsion programme.
Discharges (Faslane and Devonport)	
Main source of discharges	Faslane – The operation of the reactor produces activation products within the primary coolant circuit. Many of these are short-lived and pose no disposal problems. Devonport – Contaminated coolant and decommissioning of submarines.
Radionuclides reported under RSA93 in RIFE-13	Liquid, Faslane – Alpha, beta, H-3, Co-60. Devonport – H-3, C-14, Co-60, other radionuclides Aerial (Devonport) – Beta/gamma, H-3, C-14, Ar-41.
Abatement technology currently used by sector	Faslane – a new treatment process includes graduated filtration followed by ion exchange through 2 columns.

Defence sector – Nuclear propulsion programme	
Discharges (Derby)	
Main source of discharges	Fuel manufacture results in liquid and gaseous effluents, from which most but not all the uranium is recovered and re-used. Smaller quantities of effluent result from handling and processing legacy materials at the site.
Radionuclides reported under RSA93 in RIFE-13	Liquid – Alpha, beta. Aerial – Uranium, alpha, beta.
Abatement technology currently used by sector	Scrubbing, precipitation and filtration.
Dose to critical group	Each site <0.01 mSv/yr (calculated by site operator)
Other abatement technologies considered by sector	For nuclear propulsion plant, the great majority of liquid tritium discharges originate from neutron reaction with lithium-6 in ion-exchange resins contained in the primary cooling circuits of submarine reactors. Lithium is used to control acidity levels and prevent the build up of activated corrosion products, especially Co-60. The Government has in place a programme to use higher grade lithium with reduced lithium-6 content. The higher grade lithium can only be introduced at specific maintenance periods, which means that it will take several more years to complete the planned installations.
Other comments	Also included in the data provided are the discharges from the Vulcan Naval Reactor Test Establishment at Dounreay (chapter 10). The contribution from this site to radioactive discharges is minuscule. In addition a prediction for the final dismantling and disposal (the Interim Storage of Laid-up Submarines (ISOLUS) project) of submarines is included. The site, or sites, have not yet been chosen but will require a dock, a dedicated facility for the dismantling and packaging of the radioactive portions of the submarine and an interim store for ILW, prior to its long term disposal.
Discharge projections	Defence sector projections – see Figures 11.1 to 11.6.

Defence sector – Non-nuclear sector	
 Image supplied courtesy of MoD. Crown Copyright/MoD 2008	
Location	Two Defence Science and Technology Laboratory (DSTL) sites at Porton Down and Alverstoke. HMS Excellent near Portsmouth The Defence Support Group (DSG) and the Defence Storage and Distribution Centre (DSDC), both located at Donnington.
Overview of discharges	Training, research, sample analysis or refurbishment of military equipment is undertaken at the four operational sites. At DSDC Donnington the tritium contamination is a historic legacy.
Liquid and aerial discharges	
Nature of discharges	Aerial discharges arise from DSG at Donnington while DSTL Alverstoke and HMS Excellent make liquid discharges. DSTL Porton Down produces both aerial and liquid discharges. The levels of discharges at these sites, although extremely small, are determined by defence operational requirements. Therefore, the levels of discharge have the potential to increase as well as decrease.
Source of discharges	Breakage of gaseous tritium light sources in the refurbishment of equipment, such as prismatic compasses, released from DSG Donnington and residual tritium contamination from the decontamination of the sewage facility at DSDC Donnington. DSTL Porton Down generates radioactive waste from biosciences research. Aqueous waste is disposed of via the sewage system. Organic liquid and solid radioactive waste is disposed via on-site incineration.

Defence sector – Non-nuclear sector	
	DSTL Alverstoke operates laboratories for the analysis of radioactive samples using radioactive standards. These low level standards are discharged into the sewer.
Radionuclides reported under RSA93	H-3, C-14, phosphorus-32 (P-32), Tc-99, Cs-137.
Abatement technology	DSG Donnington used to discharge to the sewerage system but in recent years this has ended.
Dose to critical group	<0.005 mSv/yr (<0.001 mSv/yr DSDC Donnington)
Other abatement technologies considered by sector	At most sites the low levels of discharge restricts further opportunities for abatement, that is, the introduction of abatement technologies would be grossly disproportionate to the risk. At HMS Excellent the use of simulants for training purposes has been considered. This would require considerable development and the environmental impact of potential simulants would need to be determined. However, radiation dose savings would only be of the order of 1µSv per year.
Other comments	DSDC Donnington has tritium contamination in its sewage system that extends to the sewage treatment works. In 2004 extensive work was undertaken to successfully decontaminate sections of the sewage system but some residual activity remains within the system. Consideration has been given to further decontamination activities but any further radiation dose reduction to exposed persons would be minimal. Discharge levels are expected to reduce with time as tritium is gradually flushed out of the system and the remaining tritium activity reduces through natural decay. Liquid discharge projections are based on the minimum recordable level of tritium in analysed samples given in the following table and therefore the values given are the maximum. The actual discharge levels are likely to be significantly less.
Discharge projections	Defence sector projections – see Figures 11.1 to 11.6.

11.8 Sector discharge projections

Discharges projections – defence sector	
Discharge Projections	The projected liquid and aerial discharge profiles to 2030 for the defence sector are at Figures 11.1 to 11.11 below. The projections provided in this strategy are considered to be more accurate than those published in the 2002 strategy (which excluded decommissioning discharges), particularly given the improved knowledge from the completion of additional submarine refits. They are best estimates based upon present knowledge and activity levels. Discharges from the Defence Sector are determined by operational requirements; therefore levels have the potential to increase as well as decrease. Discharge predictions for aerial tritium are based on discharge limits, predominately from Aldermaston, and will not necessarily represent actual discharges.
2009 Strategy expected outcomes	By 2020: • total-alpha (liquid) discharges will have reduced to below 0.0001 TBq/yr. • total-beta (liquid) discharges will have reduced to below 0.002 TBq/yr. By 2030: • total-alpha (liquid) discharges will have reduced to below 0.0001 TBq/yr. • total-beta (liquid) discharges will have reduced to below 0.001 TBq/yr.

Figure 11.1: Total alpha discharges from defence sector (liquid)

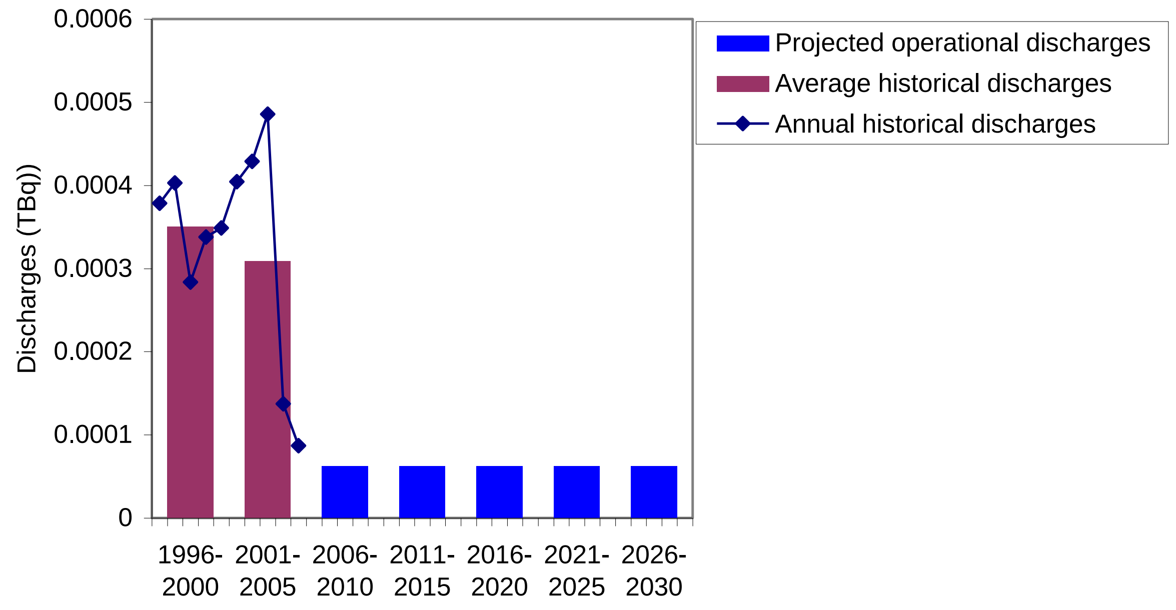


Figure 11.2: Total beta discharges from defence sector (liquid)

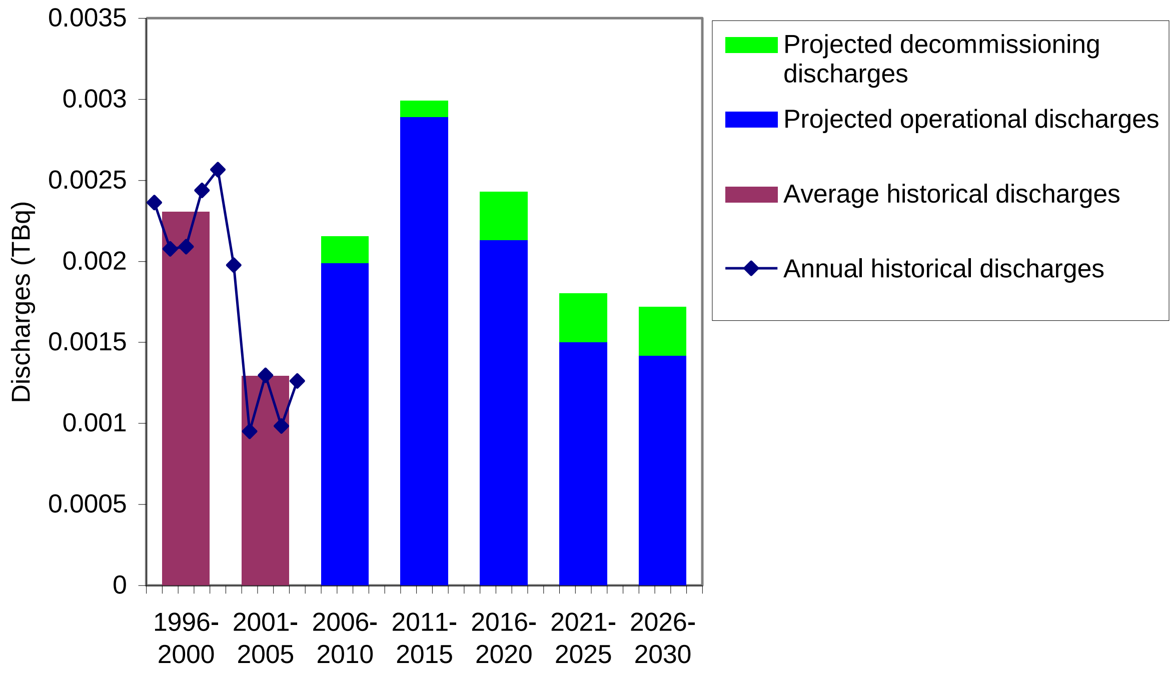


Figure 11.3: H-3 discharges from defence sector (liquid)

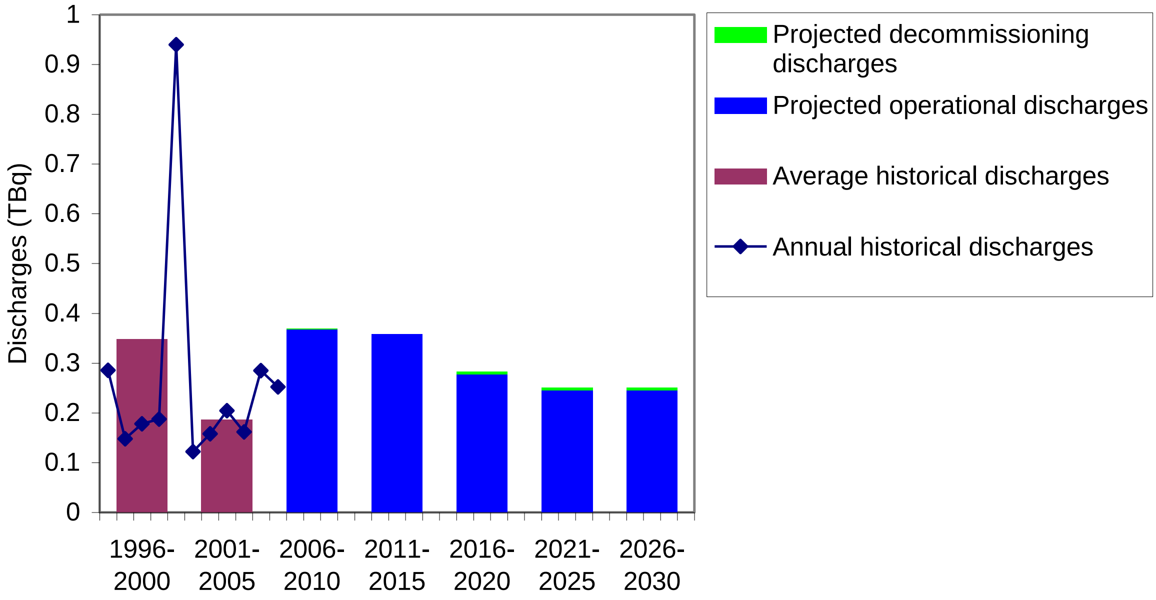


Figure 11.4: Total alpha discharges from defence sector (aerial)

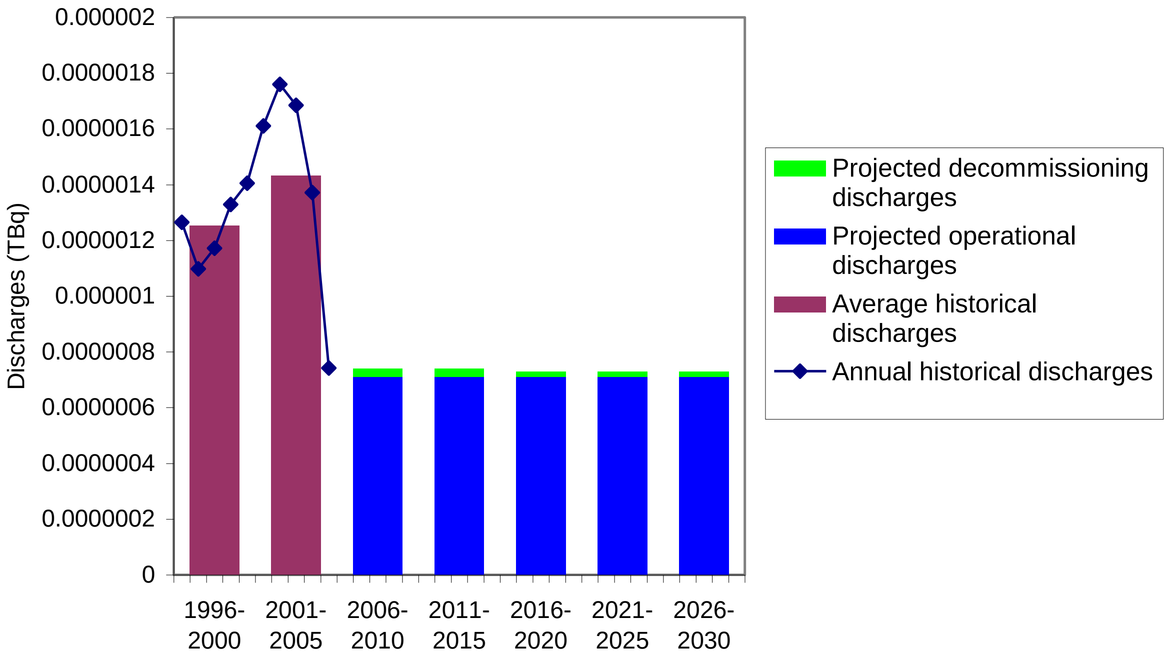


Figure 11.5: Total beta discharges from defence sector (aerial)

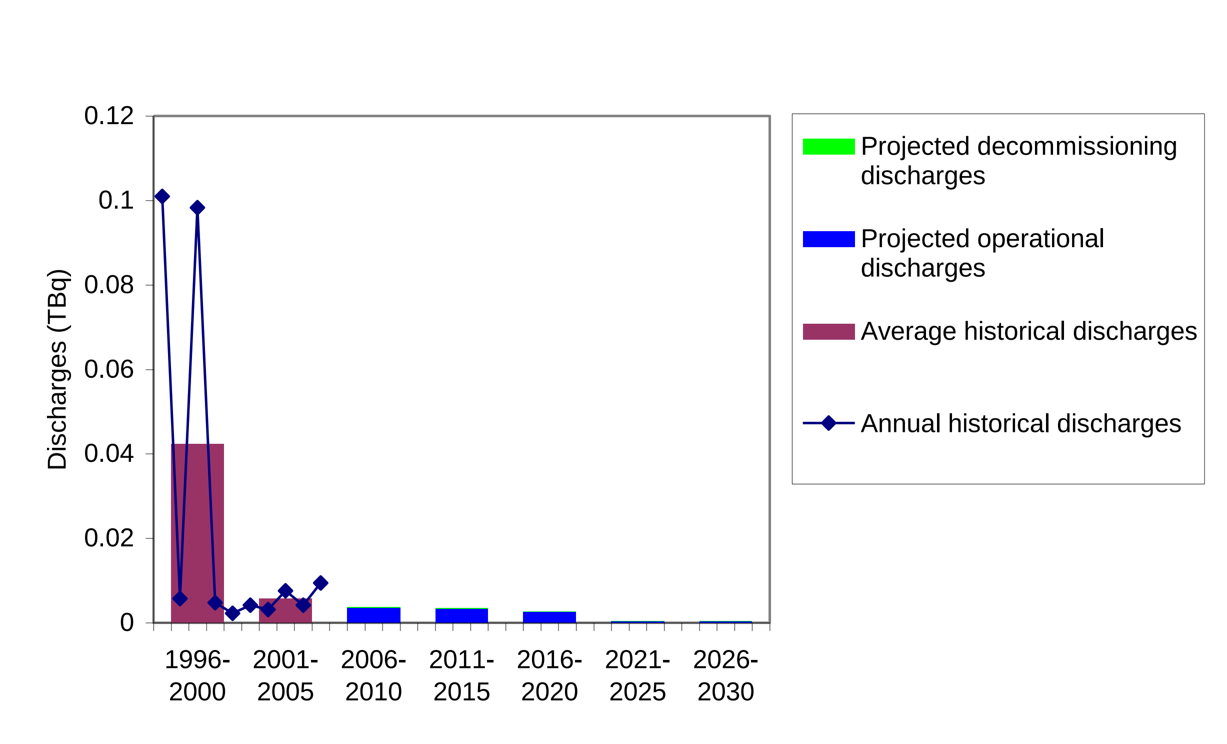


Figure 11.6: H-3 discharges from defence sector (aerial)

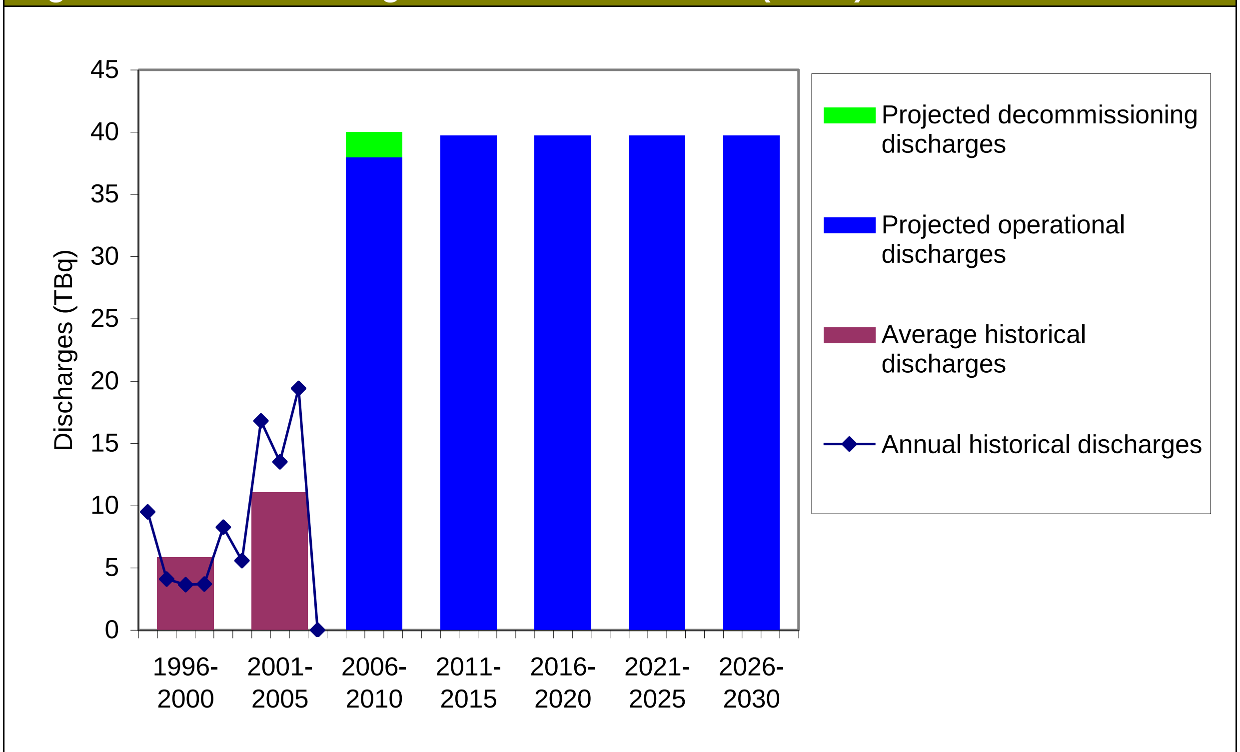


Figure 11.7: H-3 discharges from Chapelcross (liquid)

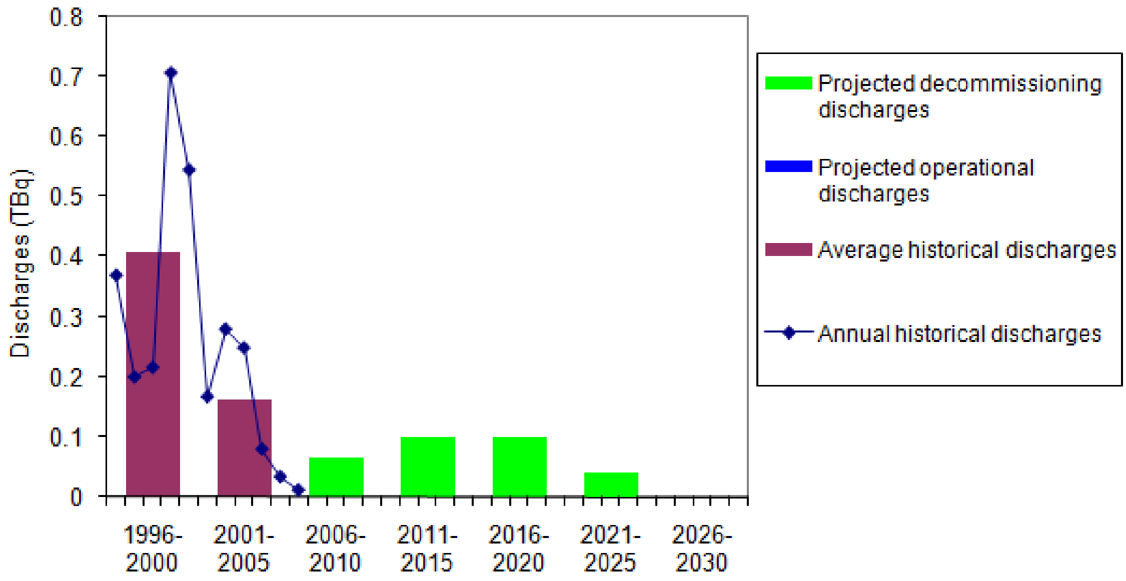
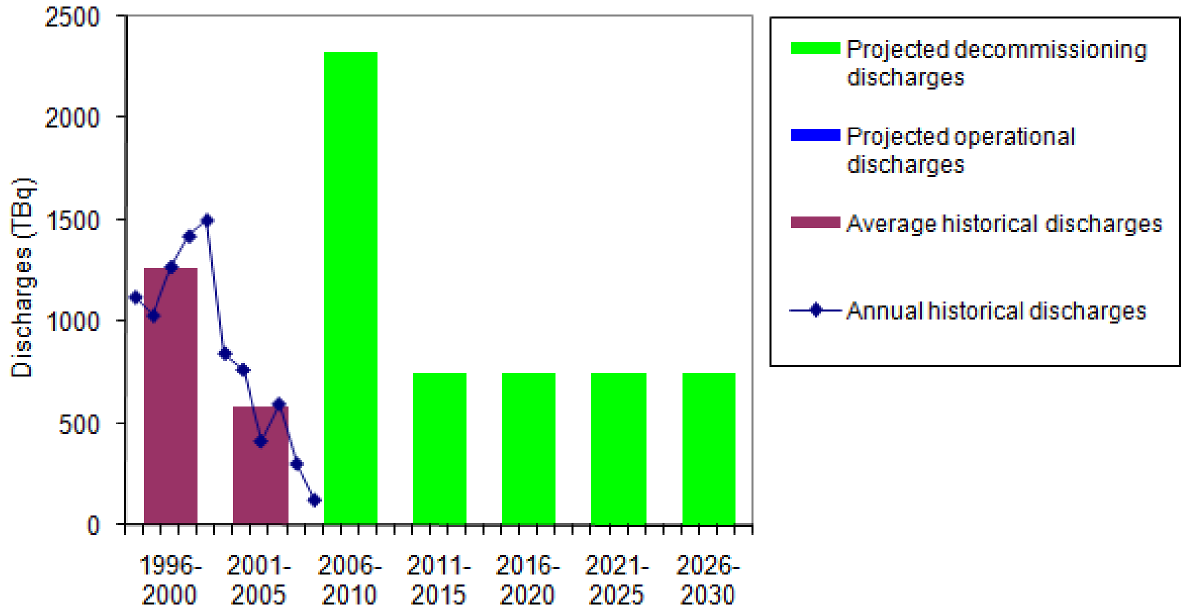
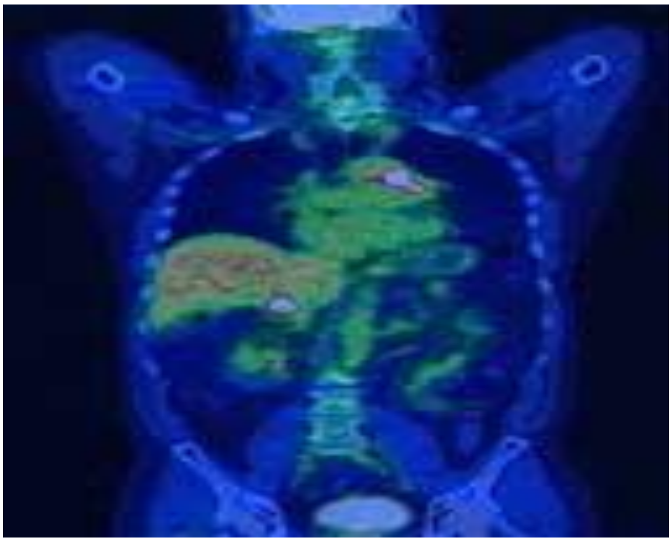


Figure 11.8: H-3 discharges from Chapelcross (aerial)



Chapter 12 - Discharges from the non-nuclear sector – isotope production & radio-labelling, medical, pharmaceutical and academic uses

Non-nuclear sector – Isotope production & radio-labelling	
 Image supplied courtesy of GE Healthcare	
Location	GE Healthcare - Maynard Centre (Cardiff), Grove Centre (Amersham) and Harwell Blychem Ltd - Billingham, Cleveland
Activities	Radiochemicals have been manufactured in the UK since the 1940s and GE Healthcare, a global healthcare company, is currently the main producer in the UK. One aspect of GE's business is the supply of radioactive products to the medical, pharmaceutical and academic sectors. A wide range of radionuclides is used in manufacturing processes and in research and development for products used in medical diagnostic tests, therapeutic treatments, drug development and life science research. Blychem Ltd is also a well-established producer of radiochemicals in the UK. GE will cease its radio-labelling operations at Cardiff in 2009.
Liquid discharges	
Main source of discharges	Cardiff - normal commercial operations until 2009. There will then be some discharges from decommissioning activities followed by discharges from management of legacy wastes. Amersham - combination of commercial operations and decommissioning activities. Harwell – Decommissioning activities. Blychem Ltd - normal commercial operations.

Non-nuclear sector – Isotope production & radio-labelling		
Radionuclides reported under RSA93	Cardiff – H-3, C-14, I-125, P-32/33 & other isotopes Amersham – H-3, Cs-137, I-125, Other alpha emitting isotopes, other isotopes.Harwell – Rn-222, Kr-85, H-3, other beta/gamma, other alpha Blychem Ltd – C-14	
Abatement technology currently used by sector	Cardiff – a Waste Treatment and Enrichment Plant (WTEP) for the recycling of appropriate liquid and aerial tritium discharges became operational in 2009 to enable tritium wastes from operations to be recycled into future raw materials. With the closure of the radio-labelling operations, this will no longer be required.	
Aerial discharges		
Main source of discharges	Cardiff - normal commercial operations until 2010 when there will be some discharges from decommissioning activities followed by longer term discharges from management of legacy wastes. Amersham - combination of commercial operations and decommissioning activities. Harwell - treatment of legacy wastes. Blychem Ltd - normal commercial operations.	
Radionuclides reported under RSA93	Cardiff – H-3, C-14, I-125, P-32/33 & other isotopes Amersham – S-35, I-125, Rn-222, other noble gases (Xenon-133), other alpha emitting isotopes, isotopes with half life less than 2 hours (fluorine-18 (F-18)), All other isotopesHarwell – Kr-85, H-3, Rn-222, other beta/ gamma particulate, other alpha particulate Blychem Ltd – C-14	
Abatement technology used by sector		
Dose to critical group	2007: Cardiff - 0.014 mSv/yr Amersham - 0.020 mSv/yr No estimate for Blychem has been calculated.	2030 (prospective dose calculated by site operator): Cardiff – <0.005 mSv/yr Amersham - <0.015 mSv/yr
Other abatement technologies considered by sector	World-wide reviews of available technologies have been conducted for GE Healthcare sites and these have shown that there are no known suitable technologies for further discharge reduction.	

Non-nuclear sector – Isotope production & radio-labelling	
Other comments	Cardiff – continuing commercial operations until around the end of 2009 or early 2010 when GE ceases radio-labelling operations followed by decommissioning of redundant facilities. Amersham – All legacy facilities are planned to be decommissioned and disposed of under current RSA93 authorisations by 2013. Manfacturing of P-32/P-33 and S-35 nucleotides, I-125 radio-labelled ligands and calcium-45, cadmium-109, chlorine-36 (Cl-36) and nickel-63 processed isotopes ceased in 2007. Harwell – Conclusion of treatment of legacy wastes expected by around 2010. It is planned that legacy facilities will be decommissioned and disposed of by 2013. Legacy wastes will be transferred to Amersham for storage pending disposal.
Discharge projections	Discharges will continue to decline as radio-labelling operations at Cardiff cease and as decommissioning of facilities at Amersham and Harwell is completed. Owing to the small size of Blychem Ltd and the uncertainties in their future business, the discharge projections given at the end of this chapter assume that future discharges from the site will continue at the same level as those in 2006. Isotope production projections – see Figures 12.1 to 12.6.

Discharge data and projections for the isotope production & radio-labelling sector

Figure 12.1: Total alpha discharges from isotope production & radio-labelling sector (liquid)

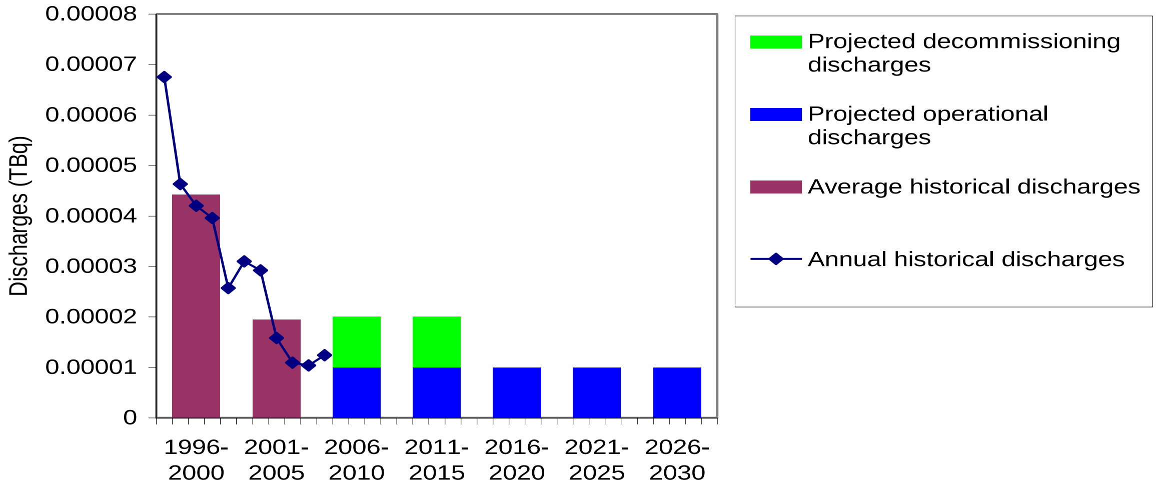
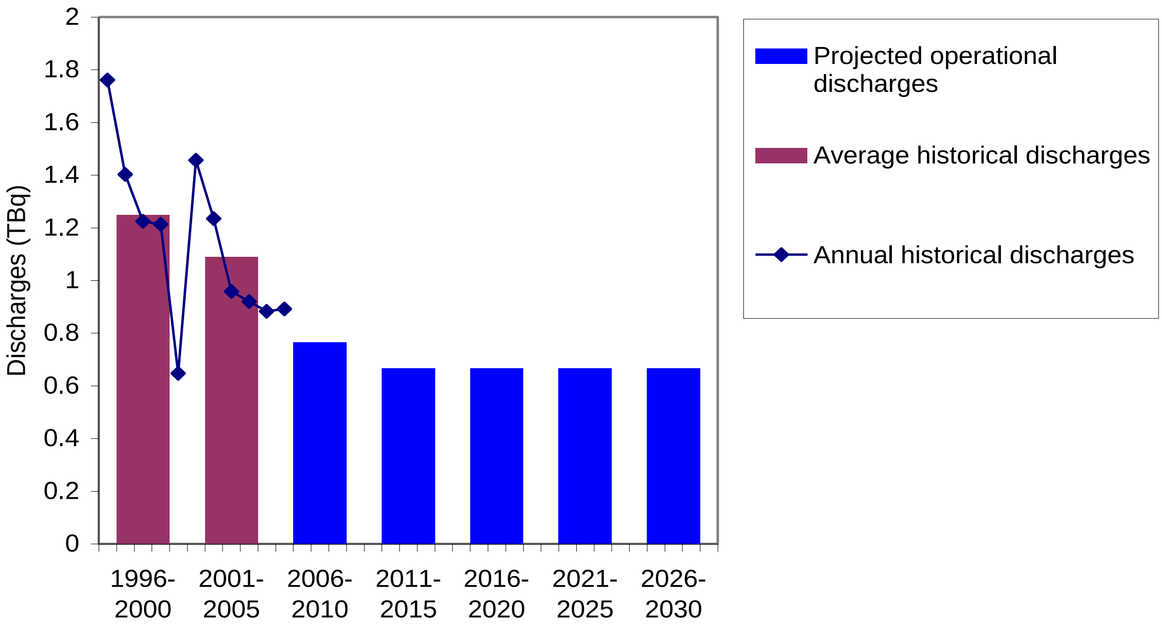


Figure 12.2: Total beta discharges from isotope production & radio-labelling sector (liquid)



* Blychem Ltd – historical discharge data only available 2001 onwards. Projected discharges assumed to be at same level as 2006 discharges (0.666TBq)

Figure 12.3: H-3 discharges from isotope production & radio-labelling sector (liquid)

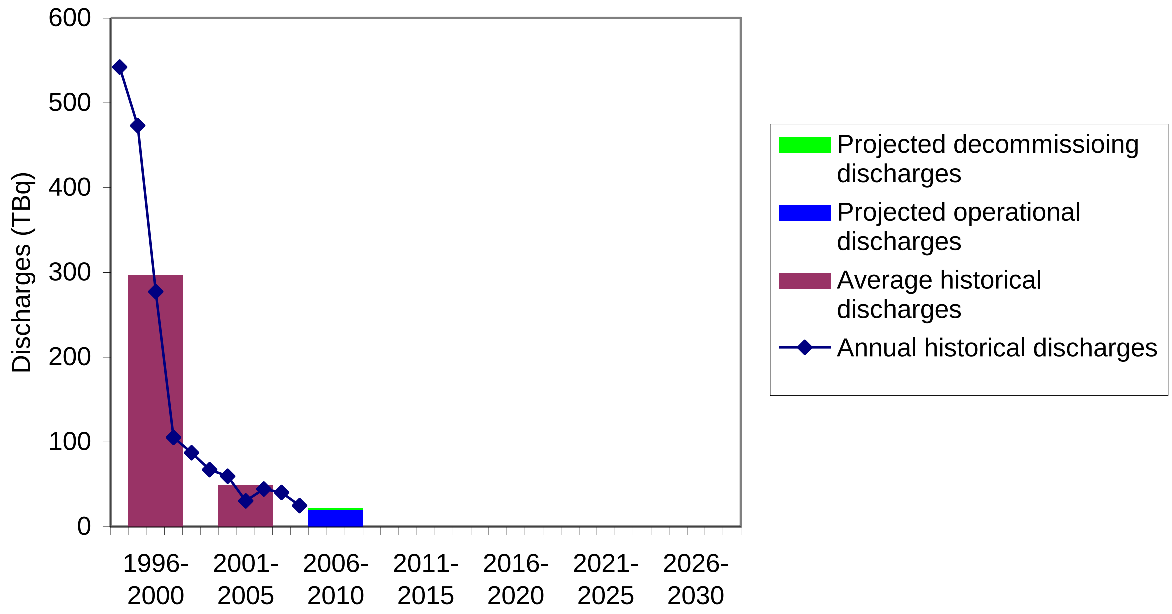


Figure 12.4: Total alpha discharges from isotope production & radio-labelling sector (aerial)

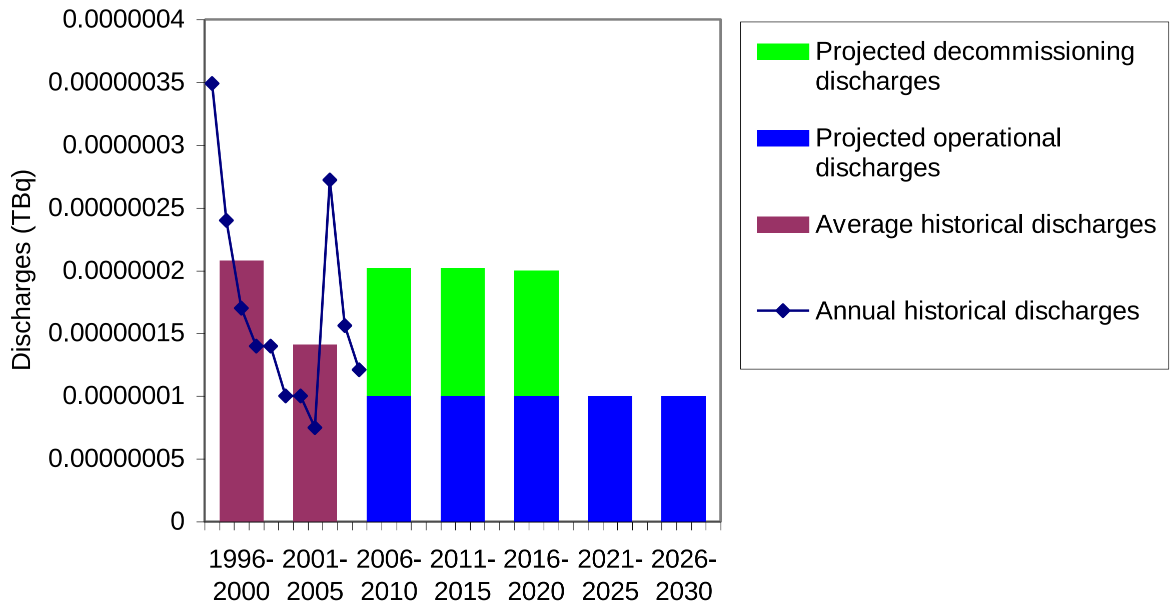
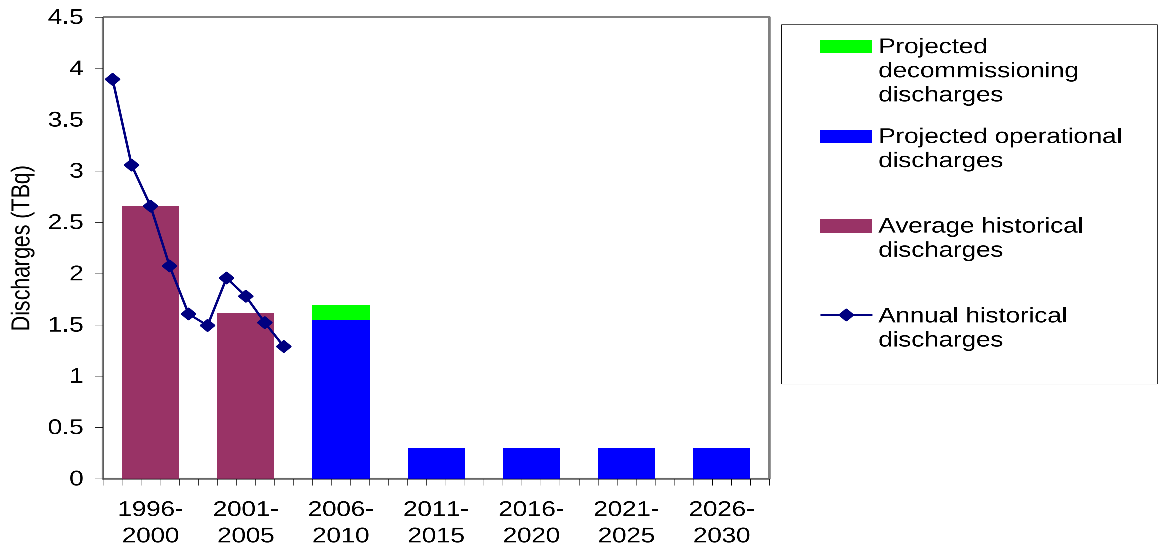
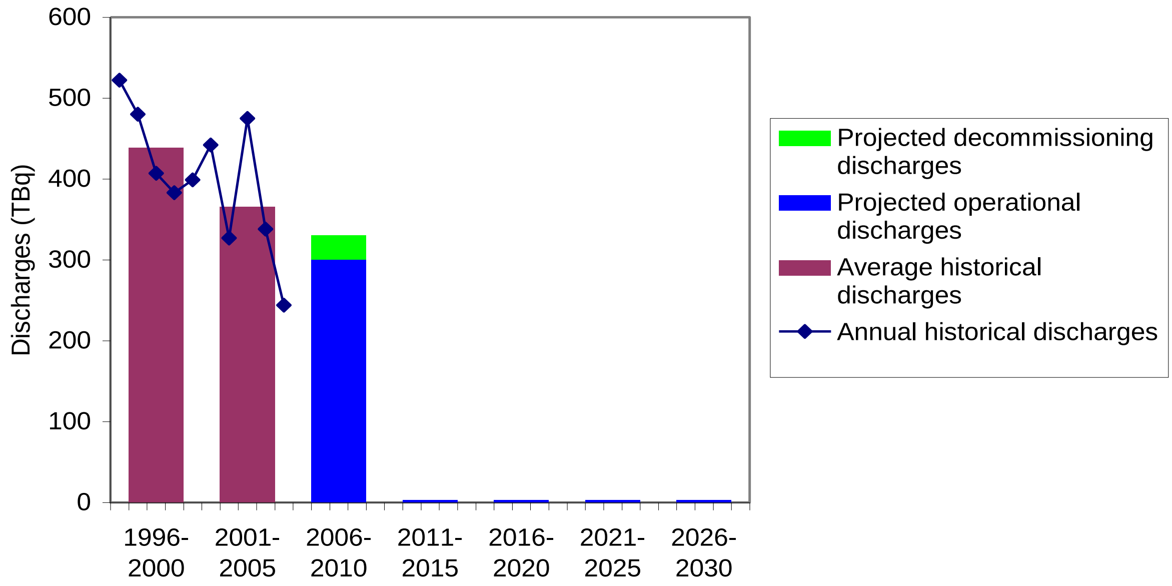


Figure 12.5: Total beta discharges from isotope production & radio-labelling sector (aerial)



Decommissioning discharges are projected for the period 2006 to 2020 but are too small to appear on this graph image.
* Blychem Ltd – historical discharge data only available 2001 onwards. Projected discharges assumed to be at same level as 2006 discharges (0.037TBq)

Figure 12.6: H-3 discharges from isotope production & radio-labelling sector (aerial)

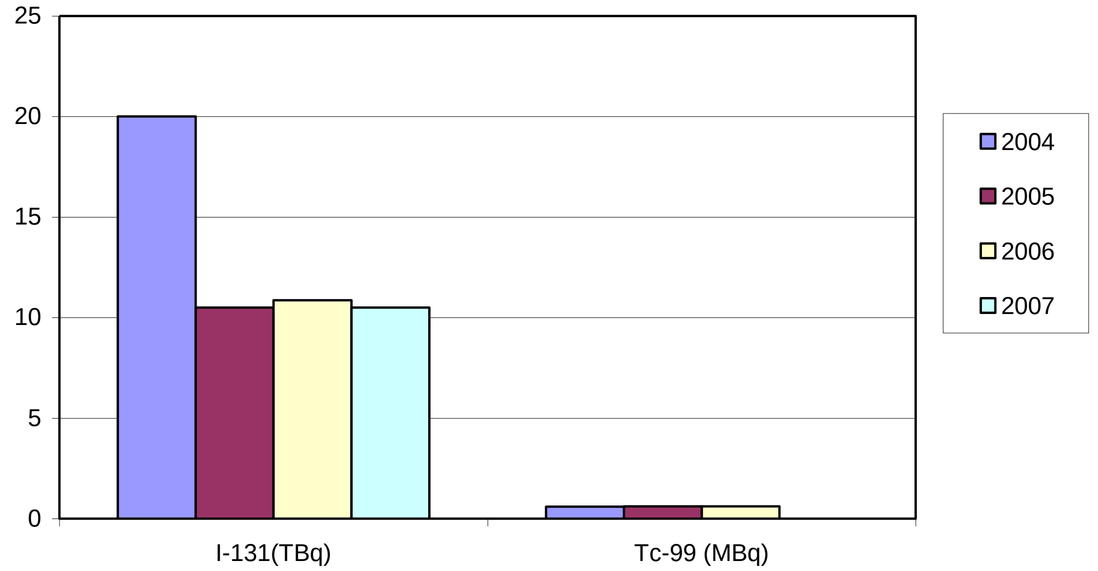


Non-nuclear sector – Medical uses of radioactive substances	
 Image supplied courtesy of Northern Ireland Cancer Centre, Belfast	
Location	Hospital nuclear medicine departments (numerous)
Activities	A number of general and teaching hospitals use radioactive materials for diagnostic and therapeutic purposes and are authorised to discharge radioactivity, mostly contained in patient excreta. The radionuclides involved are mostly short-lived (e.g. I-131). H-3, Tc-99 and C-14 are the only long-lived radionuclides of any significance in discharges from medical uses of radioactivity.
Liquid discharges	
Main source of discharges	Radiotherapy (i.e. brachytherapy and unsealed source therapy), nuclear imaging and radioactive diagnostic procedures
Common radionuclides reported under RSA-93	H-3, C-14, Tc-99, I-131, Y-90, radium-223 (Ra-223), lutetium-177, rhenium-186, Sr-89, barium-153
Abatement technology under consideration by sector	Holding tanks may be effective in reducing radioiodine discharges from large cancer therapy centres, due to short half-life of the radionuclide concerned (I-131: 8 days).
Aerial discharges	
Main source of discharges	Cyclotrons
Common radionuclides reported under RSA-93	I-131, I-125, C-14, H-3
Abatement technology currently used by sector	Filters on fume cupboards. These are changed at intervals specified by manufacturer. The filters are monitored and decay stored or disposed as radioactive waste as appropriate.

Non-nuclear sector – Medical uses of radioactive substances	
Dose to critical group	On basis of discharges made at the authorised limits, doses to sewage workers could in theory be as high as 0.238 mSv a year, using pessimistic assumptions[34]. Actual doses are likely to be much lower than this.
Other abatement technologies considered by sector	Delay tanks have been installed at some large cancer therapy facilities, such as at the new Belfast Cancer Centre, where they have been in use since March 2006.
Discharge projections	Liquid discharges have been reported to OSPAR since 2004 – see Figure 12.8. No specific discharge projections are possible for this sector, but indications of likely trends in the usage of radionuclides in medicine are given at Figure 12.9. The use of radioisotopes in medicine in the UK is increasing. Most of the activity administered is by way of radiotherapy to cancer patients, with a smaller proportion being from nuclear imaging and the use of radioactive tracers. As cancer treatments become more effective, patients have a longer life expectancy with a resulting increase in radiotherapy sessions during the follow up period, possibly extending over several years. Most treatments (around 90%) are given to outpatients, who return home afterwards. In order to reduce radiation doses to patients following treatment, the accepted procedure is to encourage frequent elimination of body wastes, thus increasing discharges to the environment.

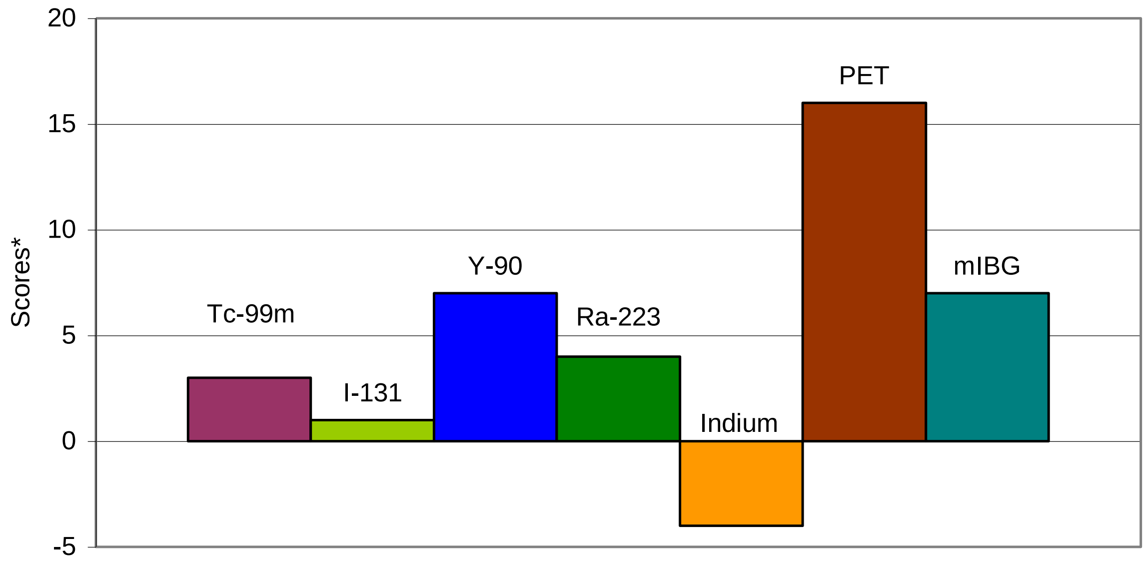
[34] Investigation of sources and fate of radioactive discharges to the public sewers. Environment Agency, 2000.

Figure 12.8: Liquid discharges from the medical sector



Note: The medical sector discharges the metastable isotope Tc-99m, which has a half-life of about 6 hours and decays to stable Tc-99 (half-life 213,000 years). Discharges are shown here (as they are reported to OSPAR) as the Tc-99 equivalent.

Figure 12.9: Likely trends in usage of radionuclides in medicine

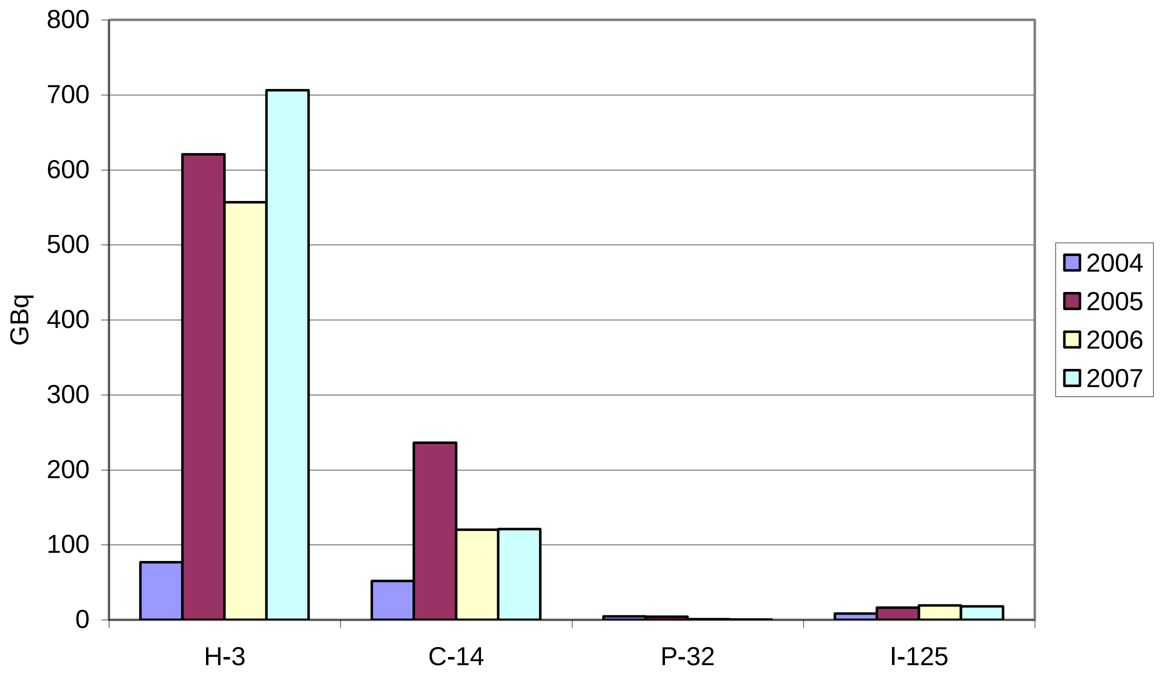


* Score reflects the number of responses from hospital oncology consultants indicating they believed use of the radionuclide or test would increase or decrease in future. Scores are not intended to indicate quantitative changes in discharges.
PET = Positron emission tomography scanning
mIBG = I-131 iodobenzylguanidine scanning

Non-nuclear sector – Pharmaceutical research & development	
 Image supplied courtesy of Newcastle University PET Centre	
Location	Various locations, main areas include Kent, London, Essex, Hertfordshire, Cheshire and Leicestershire.
Activities	The pharmaceutical sector comprises pharmaceutical research and development and clinical trials companies. Activities include drug labelling, drug target screening, clinical trials, imaging research and molecular/ cell biology research.
Liquid discharges	
Main source of discharges	Radioactive labelling used in the high-throughput screening of pharmaceutical products. Positron Emission Tomography Scanning (PET) imaging as a medical research tool.
Common radionuclides reported under RSA-93	H-3, C-14, P-32, S-35 I-125, P-33, F-18, C-11 Minor – In-111, Cr-51
Abatement technology	Local delay tanks are occasionally used for short lived radionuclides such as iodine.
Aerial discharges	
Main source of discharges	PET synthesis and use, fugitive emissions and on-site incinerator discharge
Common radionuclides reported under RSA-93	H-3, F-18, C-14, I-125, C-11, S-35

Non-nuclear sector – Pharmaceutical research & development	
Abatement technology currently used by sector	1) Local storage of solid/liquid residues for decay before incineration. 2) Fume cupboard discharges are trapped locally. 3) Engineered trapping/abatement may be installed for PET facilities
Dose to critical group	Low and vary from facility to facility.
Discharge projections	Liquid discharges have been reported to OSPAR since 2004 (within figures for "Universities and research centres") – see Figure 12.11. Discharge projections to 2030 have not been possible, due to the difficulty in making long-term business projections for this sector. For liquid discharges to sewer, the following variations on 2005 levels have been suggested to 2010: H-3: +/- 5% per year C-14 +/- 10% per year P-32 +/- 5% per year S-35 +/- 15% per year

Figure 12.10: Liquid discharges from the pharmaceuticals sector

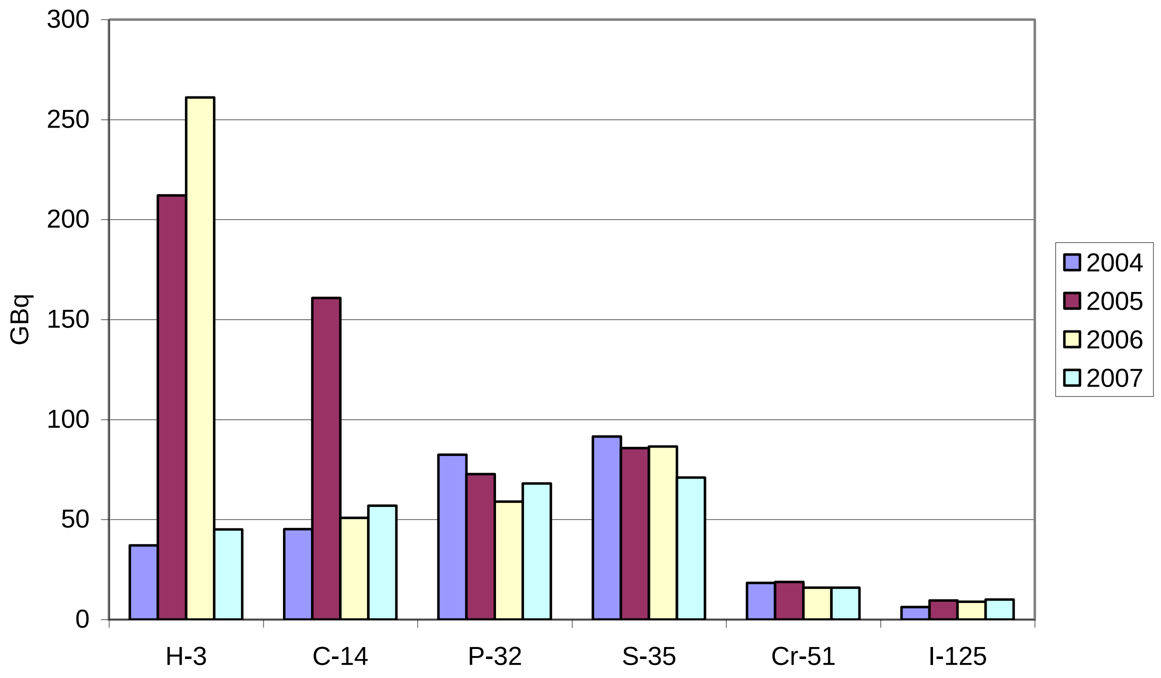


Non-nuclear sector – Academic and industrial uses

Image supplied courtesy of University of Stirling

Location	Various locations
Activities	This sector mainly comprises universities and research establishments. Some secondary schools also use small amounts of radioactive substances. Discharges are very small.
Liquid and aerial discharges	
Main source of discharges	Mainly research in the biological and biomedical sciences with particular emphasis on DNA labelling and genetics research. Aerial discharges are negligible.
Dominant radionuclides	H-3, C-14, P-32, S-35, Cr-51, I-125
Abatement technology currently used by sector	Decay storage in some cases (see below).
Dose to critical group	<0.001 mSv/yr
Other abatement technologies considered by sector	Decay storage is actively used by most users to reduce the activity of solid waste prior to disposal. This technique is not seen as viable for aqueous wastes except in relation to small volume accumulations. Delay tanks are not feasible for existing buildings as work tends to be spread out in many laboratories. Even in new build it would be hard to justify the expense given the relatively low level of discharges.
Discharge projections	Liquid discharges have been reported to OSPAR since 2004 (within figures for “Universities and research centres”) – data are at Figure 12.11. No firm discharge projections are possible for this sector. There has been a significant reduction in usage and discharges over the past 10 to 15 years and a more gradual decline is expected to continue.

Figure 12.11: Liquid discharges from the academic sector



Chapter 13 - Discharges from the non-nuclear sector – Naturally occurring radioactive materials (NORM)

13.1 NORM are radioactive materials which are naturally present in the earth's crust and have not resulted from any anthropogenic activity. Discharges of NORM may arise in the UK through the following activities:

- Onshore and offshore oil and gas facilities: NORM are injected into oil/gas reservoirs or discharged to the sea if not practicable, in the form of sludge and macerated scale deposits and in produced water.
- Energy production from fossil fuels (i.e. coal fired power stations) where aerial emissions of mostly radon and thorium are released to the environment.

13.2 There are a number of other industries which are known to discharge NORM into the environment, including: steel manufacturing, titanium dioxide industry, phosphate industry and rare-earth production.

13.3 There are three primary steel manufacturing plants in the UK. These plants operate a dry gas cleaning process and any dust removed from the stack is either recycled or sent to landfill. Therefore, there are no liquid discharges arising from this process.

13.4 There are three titanium dioxide plants in the UK, but there are no reported radioactive discharges from these plants and they do not hold authorisations to discharge radioactivity. There is no longer a phosphate industry in the UK and there is no rare-earth production.

Non-nuclear sector – Oil & Gas	
 Image supplied by courtesy of Nuvia Ltd	
Location	Offshore platforms – North Sea Decontamination facilities – Aberdeen & Winfrith
Liquid and aerial discharges – offshore oil and gas production platforms	
Main source of discharges	NORM scale accumulates as insoluble scale inside pipework and valves, and as sludge in separator tanks and other vessels. Scales and sludge must be removed so that they do not adversely affect production. There are three main sources of radioactive discharges: 1) Produced water containing soluble and particulate NORM. 2) Sand potentially contaminated with NORM entrained in a flow of water. 3) NORM scale arising from vessel cleaning, discharged in a flow of water.
Radionuclides commonly reported under RSA93	Ra-226, Ra-228, polonium-210 (Po-210), lead-210
Liquid and aerial discharges – decontamination facilities	
Main source of discharges	Scotoil (Aberdeen) and Nuvia Ltd (Winfrith) each have a decontamination facility for the removal of scale from oil and gas industry equipment. Decontamination is carried out mainly by high pressure water jetting and standard abrasive techniques. At Winfrith, these activities are undertaken within a ventilated containment area.

Non-nuclear sector – Oil & Gas	
Common radionuclides reported under RSA93	Ra-226, Ra-228
Abatement technology currently used by site operator	At Winfrith, process water is filtered and re-circulated prior to discharge via the UKAEA active effluent system. Air is extracted from the containment and passes through a HEPA filter before discharge through a stack.
Other abatement technologies considered by site operators	1) Re-injection of produced water into oil fields, although this is not technically possible in all oil fields. 2) Containment and transport of sand is not currently considered BPM due to potential significant health, safety and logistical problems. 3) Smelting of NORM contaminated steel – disposal options for the slag is being investigated. 4) In some cases, offshore equipment contaminated with LSA scale can be brought back to shore and descaled at designated onshore facilities with subsequent disposal of material to authorised sites. In the majority of cases, this is not possible for operational reasons as the equipment cannot be removed from the well, pipeline system or processing system infrastructure; therefore decontamination has to take place *in situ*. In such cases, the preferred option is disposal of the waste stream by injection beneath the seabed, but this may be impractical in some areas for technical reasons and therefore, overboard disposal to sea is used.
Discharge projections	Offshore oil and gas sector projections – see Figures 13.1 and 13.2. Most of the projected increases are due to planned decommissioning programmes and may not represent actual discharges.

Figure 13.1: Ra-226 (offshore) discharges from oil and gas sector (liquid)

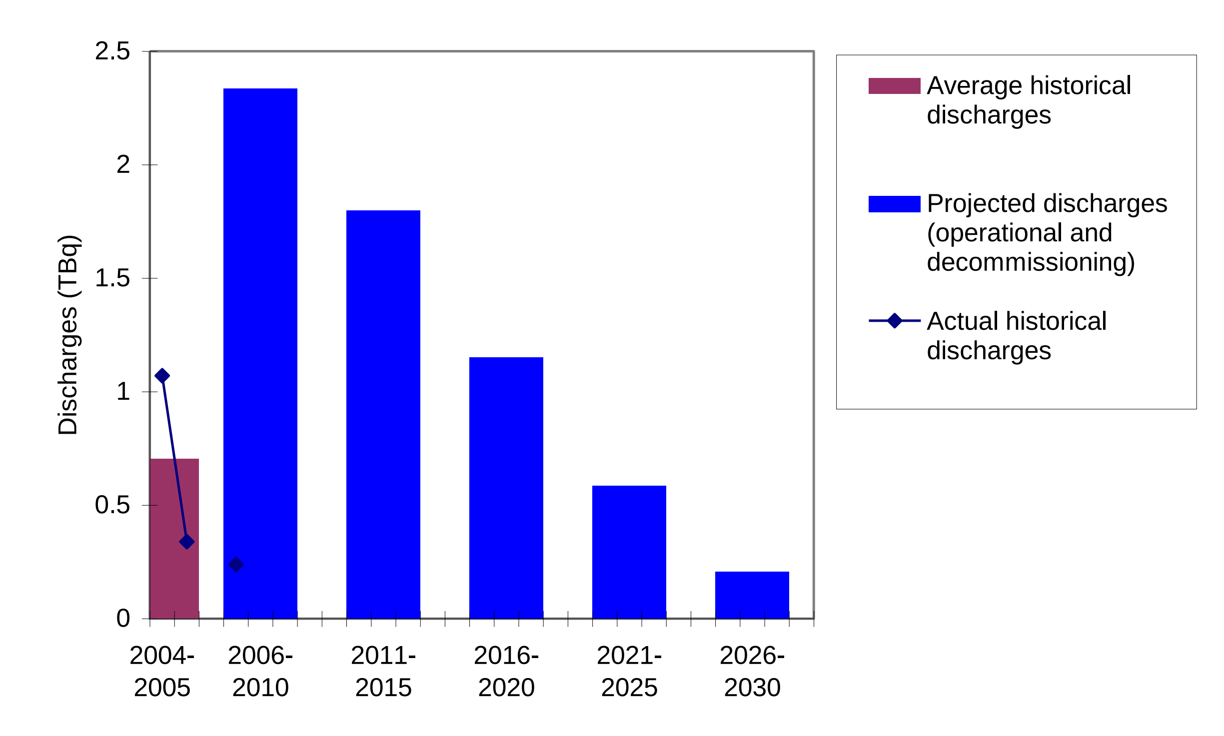
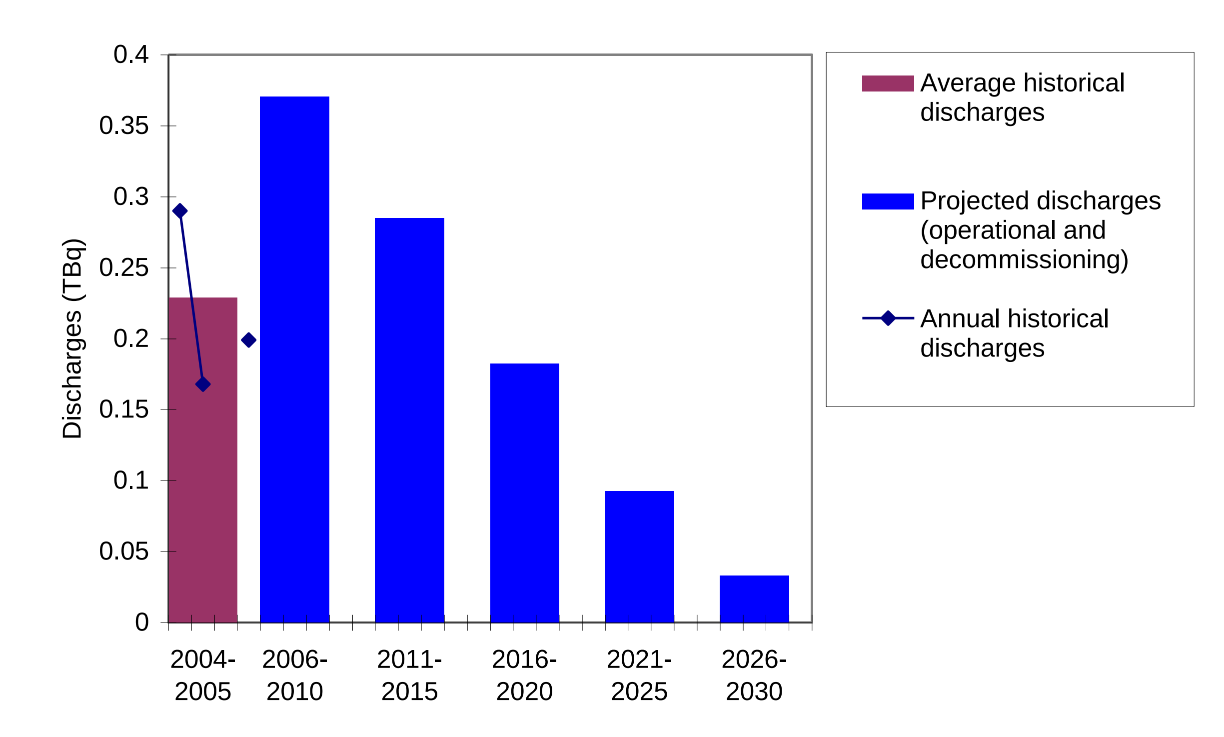


Figure 13.2: Ra-228 (offshore) discharges from oil and gas sector (liquid)



Non-nuclear sector – Coal-fired power stations	
 Image supplied courtesy of UKQAA	
Overview of discharges	The levels of radionuclides present in coal and ash and emissions to the atmosphere from coal-fired power stations are below the minimum for statutory regulation (RSA93). In addition, concentrations of radionuclides in coal and ash are below the level at which notification is required under the Ionising Radiation Regulations 1999. A 2001 NRPB (now HPA) report on the radiological impact of coal fired power stations estimated that the predicted doses to power station workers are in the region of 10 µSv/yr and the predicted peak individual dose from atmospheric releases via the stack for a typical member of the hypothetical critical group is 1.5 µSv/yr.[35]
Discharge projections	No projections have been provided.

[35] NRPB R-237, Radiological Impact on the UK population of industries which use or produce materials containing enhanced levels of Naturally Occurring Radionuclides, Part 1: Coal-fired Electricity Generation. NRPB 2001.

Chapter 14 - Discharges from the waste and incineration sector

Waste and incineration sector – Low-Level Waste Repository (LLWR)	
 Image supplied courtesy of NDA	
Location	Near the village of Drigg, Cumbria
Ownership	The site is operated by LLW Repository Ltd. and is owned by the NDA.
Activities	Receipt of low-level solid radioactive wastes from Sellafield and other nuclear and non-nuclear UK sites and its disposal in vaults on land. The LLWR consists of seven closed, unlined LLW disposal trenches, an engineered concrete LLW disposal vault, historic Plutonium Contaminated Material (PCM) storage magazines (which have been emptied of bulk PCM and are being decommissioned), a grouting facility and other supporting buildings. A new LLW Disposal Vault (Vault 9) is under construction, and future planned facilities include provision of additional modular storage vaults, and the application of UK-wide waste reduction and segregation initiatives, which will extend the capacity of the Repository until around 2070.
Decommissioning Plans	PCM storage magazines are being decommissioned.
Liquid discharges	
Main source of discharges	Leachate and rainwater run-off. The majority of activity in leachate arises from the unlined trenches.
Radionuclides reported under RSA93 in RIFE-13	Alpha, beta, H-3.

Waste and incineration sector – Low-Level Waste Repository (LLWR)	
Abatement technology currently used by operator	A “curtain wall” was constructed in the 1990s to reduce lateral migration of leachate. A trench leachate system collects liquid discharges into holding tanks, where sampling and monitoring takes place prior to discharge via a sea pipeline. An interim cap and geomembrane is in place over the historic disposal trenches to minimise water ingress into the disposed waste and thereby reduce leachate arisings.
Aerial discharges	
Main source of discharges	Decay products from decommissioning of PCM storage facilities.
Radionuclides reported under RSA93 in RIFE-13	None.
Abatement technology currently used by site operator	HEPA filtration
Dose to critical group	2007 – 0.015 mSv/yr
Other abatement technologies considered by the site operator	The site is currently the subject of a wide-ranging risk management study to ensure that the impact of operations will be kept ALARA. Options for the future management of the historical trenches are currently under review. In theory, it would be possible to dig up the trenches and repack the inventory. However, such retrieval would only be justified if its benefits were sufficient to offset potential significant increases in waste volumes, discharges and exposure of workers to radioactivity.
Other comments	Development of the repository post closure safety case is currently ongoing with a major update due to be delivered in 2011.
Discharge projections	Discharges from the LLWR will continue to be very small.

Waste and incineration sector – Waste treatment facilities	
 Image supplied courtesy of UKAEA	
Location	Various (including WMTL & AMEC Nuclear UK Ltd at Winfrith).
Activities	Wide range of operations, including (but not restricted to): analytical and testing laboratories, waste compaction, drying, cementation, treatment of organic wastes and size reduction and decontamination of metallic wastes.
Liquid discharges	
Main source of discharges	Laboratory testing and conditioning of wastes
Radionuclides commonly reported under RSA93	H-3
Abatement technology used by site operators	Secondary radioactive waste arisings are minimised through application of BPM. If WMTL relocates off the Winfrith licensed site as a result of the decommissioning of site infrastructure, it is anticipated that the new facilities will have their own liquid effluent treatment facilities that may include ion exchange and particulate filtration.
Aerial discharges	
Main source of discharges	Laboratory testing and conditioning of wastes, decontamination of metals
Radionuclides commonly reported under RSA93	H-3, C-14, Cs-137, Am-241
Abatement technology currently used by site operators	A range of BPM practices to minimise discharges including the use of HEPA filters, scrubbers and dehumidifiers. At WMTL (Winfrith), for example, conversion of tritium gas to tritiated water and recovery via bubblers to reduce tritium aerial discharges.
Dose to critical group	Low, but varies at individual sites
Other abatement	Evaporation of WMTL's liquid waste in any new facility,

Waste and incineration sector – Waste treatment facilities	
technologies considered by site operators	as an alternative to ion exchange and filtration, would provide less selective radionuclide removal. However, the cost would be significantly higher and the efficiency and reliability of such a system is less certain. For aerial C-14 removal, additional off-gas scrubbing in alkali to remove carbon dioxide has been considered. Whilst this would reduce aerial discharges it would result in higher liquid discharges or significant solid waste volumes.
	Increasing use of modern non-invasive techniques for radioactive waste assay will contribute to reducing discharges from AMEC's laboratory operations on the Winfrith site. As these are already extremely small, further reductions will be negligible in terms of discharges from the Winfrith site as a whole.
Other comments	
Discharge projections	Owing to the wide variety of activities and the large number of sites within the waste and incineration sector, it has not been possible to produce discharge projections for the sector as a whole.

Waste and incineration sector – Landfill	
 Image supplied courtesy of the Environment Agency	
Location	Various
Activities	Some organisations are authorised by the relevant environmental regulator to dispose of solid wastes containing low levels of radioactivity to approved landfill sites. The non-nuclear industry has been mainly dependent on landfill and incinerator facilities, usually provided by commercial operators, for disposal of their LLW. Government sees no reason to preclude controlled burial to landfill from any assessment of disposal options for LLW and Very Low Level Waste (VLLW) from nuclear sites, provided the necessary safety assessments can be carried out to the satisfaction of the environmental regulators.
Liquid discharges	
Main source of discharges	Leachate: Monitoring by the environmental regulators has found very low concentrations of Cs-137 in leachate and evidence of the migration of tritium from some landfill sites. Aerial discharges are not measured.
Radionuclides monitored in the environment	H-3, C-14, Co-60, Sr-90, Zr-95, Nb-95, Tc-99, Ru-106, Sb-125, I-129, Cs-137, Cs-134, Ce-144, Po-210, Th-228, Th-230, Th-232, U-234, U-235, U-238, Pu-238, Pu-239/240, Pu-241, Am-241
Abatement technology used by sector	None
Dose to critical group	2007 – <<0.005 mSv/yr
Other abatement technologies considered by sector	None considered necessary, since discharges and doses extremely low

Waste and incineration sector – Landfill	
Discharge projections	Owing to the wide variety of activities and the large number of sites within the waste and incineration sector, it has not been possible to produce discharge projections for the sector as a whole.

Waste and incineration sector - Incineration

Image supplied courtesy of Eurits

Location	Various
Activities	Disposal of combustible LLW with hazardous or toxic properties (e.g. clinical wastes) and some types of liquid wastes, such as oil.
Liquid discharges	
Main source of discharges	Scrubbing systems for incinerator off-gas systems
Common radionuclides reported under RSA93	Any beta emitters. Dominated by short-lived beta emitters (medical sector). Only one commercial incinerator in the UK is authorised to incinerate alpha emitters, very little of which would appear in liquid effluents.
Abatement technology used by sector	Not determined.
Aerial discharges	
Main source of discharges	Off gases
Common radionuclides reported under RSA93	The main discharges are volatile radiochemicals – compounds of H3, C14, S35 and various Iodine isotopes, plus small amounts of particulate matter which could contain any beta-emitter.
Abatement technology used by sector	Wet scrubbers, lime and activated carbon adsorbers, particulate filters
Dose to critical group	Usually <0.02 mSv/year per incinerator.
Other abatement technologies considered	None.

Waste and incineration sector - Incineration	
Other comments	Partitioning during the incineration process leads to the vast majority of activity (as metal oxides) being concentrated in incinerator ash. Since the closure of most incinerators on nuclear sites and at medical establishments, some commercial incinerators burn radioactive materials alongside large volumes of non-radioactive waste. The dilution factor means that most incinerator ash can subsequently be disposed of as VLLW or is exempt. There are a few specialised clinical waste incinerators.
Discharge projections	Owing to the wide variety of activities and the large number of sites within the waste and incineration sector, it has not been possible to produce discharge projections for the sector as a whole.

Waste and incineration sector – Geological Disposal Facility

Underground transport facilities at a disposal facility in Sweden (courtesy SKB)

Location	To be decided under the Government's Managing Radioactive Waste Safely (MRWS) programme.
Activities	Under the MRWS framework the UK Government has a policy of geological disposal, preceded by safe and secure interim storage, for the long-term management of the UK's higher activity radioactive wastes. The Scottish Government did not endorse the consultation on deep geological disposal in 2007. The policy for Scotland is to support long term "near surface, near site" storage facilities so that waste can be monitored, is retrievable and the need for transporting it over long distances is minimised. The Radioactive Waste Management Directorate (RWMD) of the NDA has responsibility for implementing geological disposal. Many sites are already conditioning and packaging wastes ready for disposal, working to packaging standards defined by the RWMD. Packaging advice is given to sites through the RWMD's Letter of Compliance assessment process. It is highly unlikely that any future geological disposal facility would be operational within the period covered by this version of the strategy. Future discharges from such a facility do not form part of any forecasts, but are described in this section for information.

Waste and incineration sector – Geological Disposal Facility	
Liquid discharges	
Main source of discharges	Discharges occurring beyond the timescale covered by this strategy would include those from the operational phase from groundwater drainage systems and effluents from cleaning, maintenance and decontamination of, for example, reusable transport containers.
Radionuclides likely to be reported	C-14, Cl-36, I-129
Abatement technology	Use of BAT is expected to include effluent treatment facilities, engineered containments and barriers.
Aerial discharges	
Main source of discharges	During the construction and operational phase, beyond the timescale of this strategy, ventilated discharges from vented waste packages emplaced in the Geological Disposal Facility and from the surrounding rocks. Very small levels of particulate radioactivity arising from contamination on the surfaces of waste packages in the unlikely event of a package failure.
Radionuclides likely to be reported under RSA93	H-3, C-14, Rn-222 and its daughter radionuclides.
Abatement technology	Use of BAT is expected to include HEPA ventilation filters to remove particulate matter.
Dose to critical group	Regulators will require the Geological Disposal Facility to be designed such that, among other requirements, it can be demonstrated that, after the period of authorisation, the assessed radiological risk from a disposal facility to a person representative of those at greatest risk should be consistent with a risk guidance level of 10^{-6}/year (i.e. 1 in a million per year).
Other abatement technologies considered	The development of a disposal facility will take into account radioactive waste minimisation and containment techniques. The choice of techniques to minimise aerial and liquid discharges will be optimised to take into consideration potential solid waste arisings.
Other comments	Defra, DECC, the EA and the Welsh Assembly Government are currently consulting on proposals that intrusive investigations and construction of a facility would be subject to staged authorisation by the environmental regulator.

Waste and incineration sector – Geological Disposal Facility	
Discharge projections	As no location has been chosen, and therefore no concept or design selected yet, it is not possible at present to make precise predictions of future discharges that might arise from a deep geological disposal facility, but the regulators will ensure the use of BAT so that any discharges are minimised. The indicative timescale for development of the disposal facility is several decades, so any future discharges from this source are unlikely to have an impact in the timeframe of this strategy.