Department of Energy & Climate Change

Lead Document setting out the United Kingdom's National Programme for the Responsible and Safe Management of Spent Fuel and Radioactive Waste

August 2015

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List of Abbreviations and Acronyms

AGR	Advanced Gas-Cooled Reactor
BE	British Energy
Bq	Becquerel, the unit of radioactivity (one disintegration per second)
CLESA	Calder Landfill Extension Segregated Area
CoRWM	Committee on Radioactive Waste Management
DECC	Department of Energy & Climate Change
DA's	Devolved Administrations of Scotland (the Scottish Government), Wales (the Welsh Government) and Northern Ireland (the Northern Ireland Executive)
DNLEU	Depleted, natural and low-enriched uranium
DSTC	Disposal shielded transport container
DFR	Dounreay Fast Reactor
EA95	Environment Act 1995
EC	European Commission
EDFE	EDF Energy Nuclear Generation
EIADR99	Environmental Impact Assessment for Decommissioning Regulations
EPR10	Environmental Permitting (England and Wales) Regulations 2010
ESC	Environmental Safety Case
EU	European Union
FDP	Funded Decommissioning Programme
GBq	Giga-Becquerel
GDA	Generic Design Assessment
GDF	Geological disposal facility
GRA	Guidance on Requirements for Authorisation
gDSSC	generic Disposal System Safety Case
HAL	High activity liquor
HALES	High Active Liquor Evaporation and Storage
HASS	High activity sealed source
HAW	Higher activity wastes
HLW	High-level waste
HVLA	High volume low activity
ILW	Intermediate-level waste
IPRI	Industrial Pollution and Radiochemical Inspectorate
kBq	kilo-Becquerel
LLW	Low-level waste
LLWR	Low Level Waste Repository
LoC	Letter of compliance
LWR	Light water reactor
MAC	Miscellaneous activated components
MBq	Mega-Becquerel
MEP	Magnox encapsulation plant
MoD	Ministry of Defence
MOP	Magnox Operating Programme
MOX	Mixed (i.e. uranium + plutonium) oxide fuel
MRWS	White Paper "Managing Radioactive Waste Safely" 2008
MW(e)	Megawatt (electrical)
MW(th)	Megawatt (thermal)
NDA	Nuclear Decommissioning Authority

NI	Northern Ireland
NIA65	Nuclear Installations Act 1965
NIEA	Northern Ireland Environment Agency
NIRAB	Nuclear Innovation and Research Advisory Board
NIS	Nuclear Industrial Strategy
NLF	Nuclear liabilities fund
NLFAB	Nuclear Liabilities Financing Assurance Board
NORM	Naturally occurring radioactive material
NPS	National Policy Statement
NRW	Natural Resources Wales
ONR	Office for Nuclear Regulation
PBO	Parent Body Organisation
PCM	Plutonium Contaminated Material
PFR	Prototype fast reactor
POCO	Post operation clean out
PWR	Pressurised water reactor
REPPIR01	Radiation Emergency Preparedness and Public Information Regulations
RSA93	Radioactive Substances Act 1993
RSP	Relevant Statutory Provisions
RWM	Radioactive Waste Management Limited
RWMC	Radioactive Waste Management Case
R&D	Research and Development
SEA	Strategic Environmental Assessment
SEPA	Scottish Environment Protection Agency
SGHWR	Steam generating heavy water reactor
SILW	Shielded ILW
SLC	Site licence company
SNF	Spent nuclear fuel
SRTC	Shielded reusable transport container
TBq	Tera-Becquerel
TFS	Trans-Frontier Shipment
tHM	Tonnes of heavy metal
THORP	Thermal Oxide Reprocessing Plant
UILW	Unshielded ILW
UKAEA	UK Atomic Energy Authority
UK Government	UK Government at Westminster responsible for matters reserved to Westminster
VLLW	Very low-level waste
WAGR	Windscale AGR
WVP	Waste Vitrification Plant
ZEBRA	Zero Energy Breeder Reactor Assembly

Chapter 1 Introduction

Purpose of the Lead Document

1.1 Council Directive 2011/70/EURATOM (the 2011 Directive) requires European Union (EU) Member States to have National Programmes for the implementation of their management policies for the spent fuel and radioactive waste that falls within the scope of the Directive[1]. This document provides an overview of the UK's (United Kingdom of Great Britain and Northern Ireland) National Programme that supports the requirement under Articles 13 and 15 of the 2011 Directive to notify the Commission of our National Programme by 23 August 2015. The document covers the range of policies, strategies and approaches within the four countries (England, Scotland, Wales and Northern Ireland) that make up the UK.

1.2 This lead document has been produced for the purposes of demonstrating compliance with Articles 13 and 15 of the Directive rather than being produced as a public information document. However, in line with the UK Government's approach on transparency this document will be made openly available on the UK Government website.

1.3 The 2011 Directive also requires Member States to submit, on a triennial basis, a National Report on progress made on implementing the Directive including progress made on implementing the National Programme. In line with Article 13, any subsequent significant changes to the National Programme will be notified to the Commission as and when they occur.

Structure of this Document

1.4 The Lead Document has been prepared by the Department of Energy and Climate Change (DECC) with the cooperation of the Devolved Administrations, waste management organisations and regulators. It is intended to be accessible and high-level; a list of acronyms and abbreviations is provided and frequent references throughout the text show where more detailed information can be found. Definitions are as listed in Article 3 of the 2011 Directive. It broadly follows the proposed generic structure for a lead document as contained in Annex VI of the European Nuclear Energy Forum's Guidelines for the Establishment and Notification of National Programmes.

1.5 This chapter continues with an overview of the nature and sources of radioactive waste and spent nuclear fuel (SNF) in the UK. Chapter 2 outlines the UK's transparency policy, and policies for radioactive waste

[1] The Directive does not apply to authorised releases (discharges) of radioactive waste to air and water or to radioactive waste that is produced on onshore extractive industries, which falls within the scope of Directive 2006/21/EC. Article 4 of the Directive does not apply to: repatriation of sealed sources; shipment of spent fuel of research reactors to a supplier or manufacturer; shipments of radioactive waste for processing or recovery of radioactive waste; and radioactive waste (or an agreed equivalent) arising from treatment or reprocessing of spent fuel.

management and the associated regulatory framework. Chapter 3 relates to the UK's Radioactive Waste Inventory and existing and future holdings of SNF. Chapters 4 to 7 describe how the main waste types are managed and Chapter 8 does the same for SNF. Chapter 9 is concerned with the development and maintenance of skills and the organisation of research. Chapter 10 explains how the management of SNF and radioactive waste is funded in the UK. Chapter 11 describes the key performance indicators for monitoring progress on the implementation of the National Programme, relating them back to the previous chapters. Finally, Chapter 12 supplies the relevant references.

Background

UK Government and Devolved Administrations

1.6 Three devolved administrations for Scotland, Wales and Northern Ireland were established in the late 1990s. These devolved administrations are able to exercise powers in relation to certain areas, including environmental protection and radioactive waste management. This creates the potential for some differences in the way that certain categories of waste are managed across the UK. While Northern Ireland has no nuclear facilities, radioactive waste arising from the non-nuclear sector is managed in line with UK Government and Devolved Administrations' policy for Low-Level Waste (LLW) and Very Low-Level Waste (VLLW).

1.7 When the term 'UK Government' is used in this document it refers to the Government at Westminster, responsible for all matters relating to England and for those matters where powers have not been conferred on Welsh Ministers or devolved to Scottish Ministers or to Northern Ireland Ministers and departments. Examples of reserved matters (excepted in relation to Northern Ireland) include nuclear security and nuclear safety.

Waste Classification in the UK

1.8 Material that has no further use, and is contaminated by, or incorporates, radioactivity above levels defined in UK legislation [Refs 1, 2] is known as radioactive waste. This ranges from nuclear industry waste containing high concentrations of radioactivity to general industrial and medical wastes that contain low concentrations of radioactivity.

1.9 Radioactive wastes are classified in terms of the nature and quantity of radioactivity they contain and their heat-generating capacity, as shown below:

Low Level Wastes (LLW)

Wastes having a radioactive content not exceeding 4 GBq (gigabecquerels) per tonne of alpha, or 12 GBq per tonne of beta/gamma activity.

Intermediate Level Wastes (ILW)

Wastes exceeding the upper boundaries for LLW, but which do not require heating to be taken into account in the design of storage or disposal facilities.

High Level Wastes (HLW)

Wastes exceeding the upper boundaries for LLW, in which the temperature may rise significantly as a result of their radioactivity, so that this factor has to be taken into account in the design of storage or disposal facilities.

1.10 VLLW is a sub-category of LLW that may comprise one of the following two descriptions [Ref 3]:

- Low Volume VLLW ('dustbin loads') - wastes that can be safely disposed of to an unspecified destination with municipal, commercial or industrial waste, each 0.1 cubic metre of material containing less than 400kBq (kilo-Becquerels) of total activity, or single items containing less than 40kBq of total activity. There are additional limits for carbon-14 and tritium in wastes containing these radionuclides.

- High Volume VLLW (bulk disposals) – wastes with maximum concentrations of 4MBq (mega-Becquerels) per tonne of total activity. There is an additional limit for tritium in wastes containing this radionuclide.

1.11 The first VLLW category enables low volume producers to mix Low Volume VLLW with other wastes at the point of arising and send it to landfill under exemption provisions. Producers of both Low Volume and High Volume VLLW are able to send their wastes to suitable landfill sites under exemption provisions.

1.12 The approach across the whole of the UK recognises higher-activity waste (HAW), which includes three waste types:

- vitrified HLW resulting from reprocessing;

- ILW arising from power station operations, reprocessing of SNF and decommissioning of nuclear facilities; and,

- LLW with concentrations of specific long-lived radionuclides that make it unsuitable for disposal at the existing Low Level Waste Repository (LLWR) in Cumbria.

Use of Radioactive Materials in the UK

1.13 The use of nuclear technology, first for defence purposes and later for electricity generation, has a long history in the UK. There have been many different designs of research, prototype and nuclear power plant reactors that have been built and operated since the UK started its nuclear programme in the late 1940s. Radioactive substances have been and continue to be used in activities such as electricity generation, defence, industry, medicine and research & development. The last of these has been extensively used to support the expansion and improvement of nuclear power through, for example, new reactor types and various fuel cycles. Additionally, the UK has had programmes for reprocessing spent nuclear fuel (both from UK reactors and from overseas customers) at the Sellafield and Dounreay sites (though the programme at Dounreay has now ceased).

1.14 All these activities produce radioactive waste. Much LLW / VLLW has been disposed already to the LLWR and other near-surface facilities. A larger amount of LLW/VLLW currently exists only as "committed" waste i.e. waste that will certainly arise in the future as reactors and other facilities are operated and then decommissioned. Radioactive waste that cannot be disposed to surface facilities is held in storage pending disposal.

1.15 Figure 1-1 shows the locations of the UK's nuclear installations and disposal sites.

Nuclear Sector

1.16 The Energy Act 2004 [Ref 4] created the Nuclear Decommissioning Authority (NDA) and gave it the responsibility for operating and decommissioning all the civil UK nuclear sites that were then in state ownership. The NDA is the strategic authority with responsibility for the civil public sector nuclear estate. It is responsible for 17 of the UK's 19 historical nuclear sites, their liabilities and assets, including the first generation of Magnox power stations, various research and fuel facilities, the LLWR, and the largest, most complex site, Sellafield. The NDA sites are the current location of most of the wastes listed in the UK Inventory[2].

1.17 As strategic authority, the NDA's core objective is to ensure that these sites are decommissioned safely, securely, cost-effectively and in ways that protect the environment. The NDA is the body that secures and allocates funding for decommissioning and clean-up of the UK civil, public-sector nuclear sites, including long-term radioactive waste management, working with a wide range of stakeholders in the UK and overseas to ensure that:

[2] The UK Radioactive Waste & Materials Inventory (the "UK Inventory") is the latest national record on radioactive wastes and materials in the UK. The Inventory is updated every three years. It is a snapshot of wastes and materials at a specific point in time, called the 'stock date'. It can be viewed at: https://www.nda.gov.uk/ukinventory/

- the right options are considered and chosen in line with relevant Government policy;
- the right plans are in place for the long-term;
- the right contract models incentivise the safest and most cost-effective clean-up;
- the right skills and resources are available;
- the right technology is developed; and,
- local communities are supported during and after the clean-up mission.

1.18 The NDA's strategy is underpinned by a commitment to encourage the highest reasonably practicable standards of safety, security and environmental responsibility and an open and transparent approach to secure the support and trust of stakeholders.

1.19 Day-to-day management of the NDA's 17 sites is contracted out to individual Site Licence Companies (SLCs). As operators and licence holders, the SLCs have prime responsibility for the safety of their sites. The role of the NDA is to ensure that the activities of the SLCs are consistent with NDA core objectives (1.17-1.18). Included in these arrangements is the Low Level Waste Repository (LLWR) which, as the only national disposal site for LLW, is owned by the NDA and operated on its behalf by a SLC.

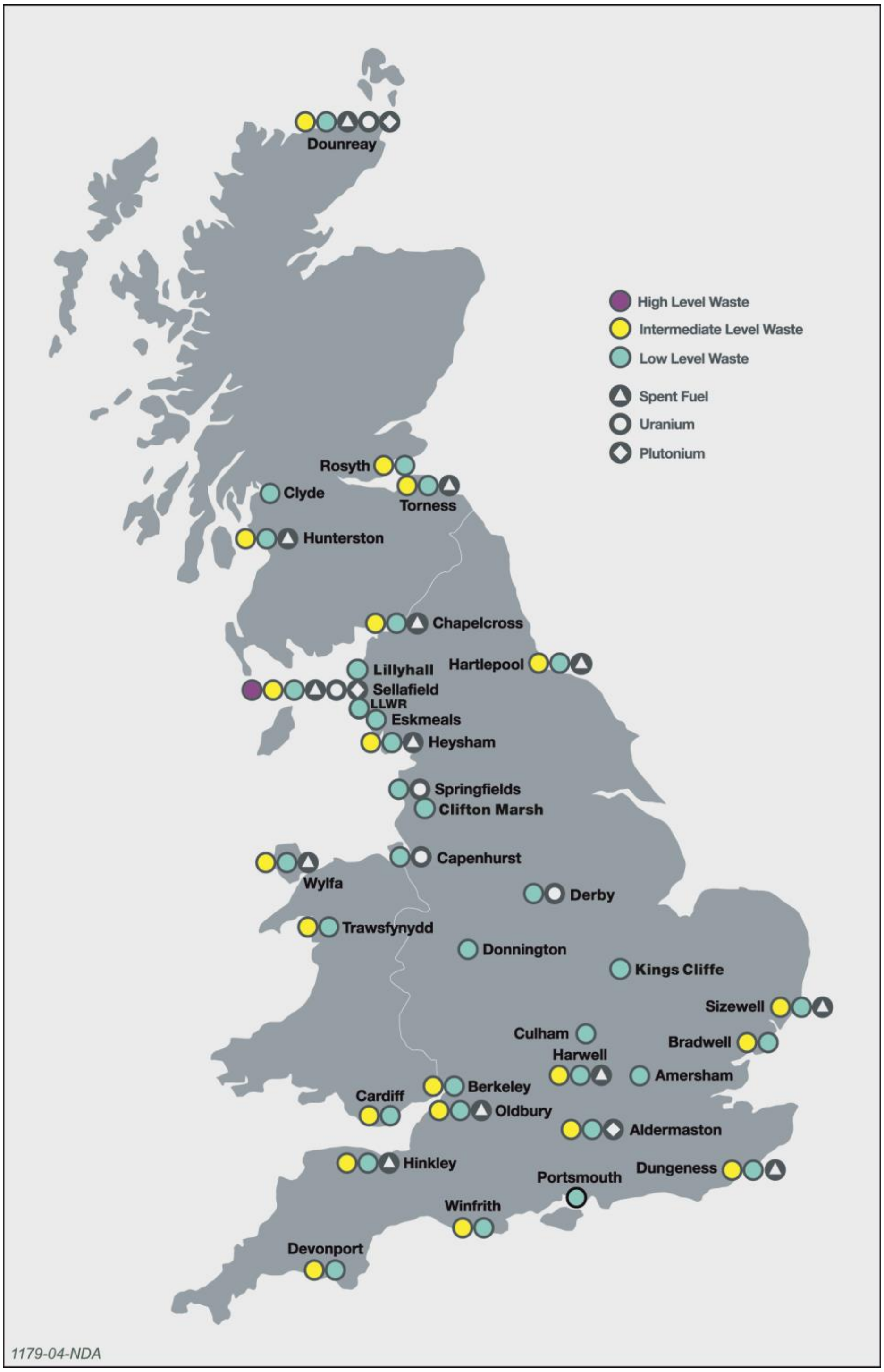
1.20 Two of the original NDA sites - Springfields and Capenhurst – were subsequently sold to private enterprises. This was to enable them both to continue and expand their operations (nuclear fuel manufacturing and enrichment) that were already being performed there. The sales also transferred the associated non-historical decommissioning liabilities from the NDA to the private sector.

1.21 Other major sources of radioactive waste are the privately operated nuclear power plants. These consist of seven Advance Gas-Cooled Reactors (AGR) and the one Pressurised Water Reactor (PWR) nuclear power plants, all of which were privatised in 1996 and are now owned by EDF Energy Nuclear Generation (EDFE). There are contracts in place under which the NDA takes ownership of the SNF produced by the AGR fleet. The PWR SNF will stay in the ownership of EDFE until it is finally accepted by a Geological Disposal Facility (GDF). Similarly, all the radioactive waste produced by the operation and decommissioning of these plants remains the responsibility of EDFE until they are accepted for disposal.

Non-nuclear Sector

1.22 The non-nuclear industry is defined as those organisations that produce radioactive waste and are not part of the nuclear industry. Most non-nuclear industry organisations use radioactive materials as a vital part of their day-to-day operations; for example medical, pharmaceutical, research and educational establishments. Other organisations process material that contains natural radioactivity, for instance the oil and gas extraction and mineral sands industry. Common to all of these organisations is that they generate waste containing low levels of radioactivity which requires management and that may be subject to regulation. Future decommissioning of offshore oil and gas platforms may significantly increase the amount of Naturally Occurring Radioactive Material (NORM) waste to manage; the UK is currently implementing the UK NORM waste strategy to help manage all such wastes in the future.

Figure 1-1 Map of UK Nuclear Sites



Nuclear “New Build”

1.23 The UK envisages that a new generation of nuclear power plants are to be built in England and Wales. Because these plants are still at the planning stage, the SNF and the waste that they will produce are not yet “committed”. For that reason the waste does not appear in the current version of the UK Inventory. The arrangements that have been put in place for managing waste and SNF from the new build generators are, nevertheless, outlined in Chapters 8 and 10, and the UK Inventory is updated on a regular basis. No nuclear new build is currently being proposed for Scotland or Northern Ireland.

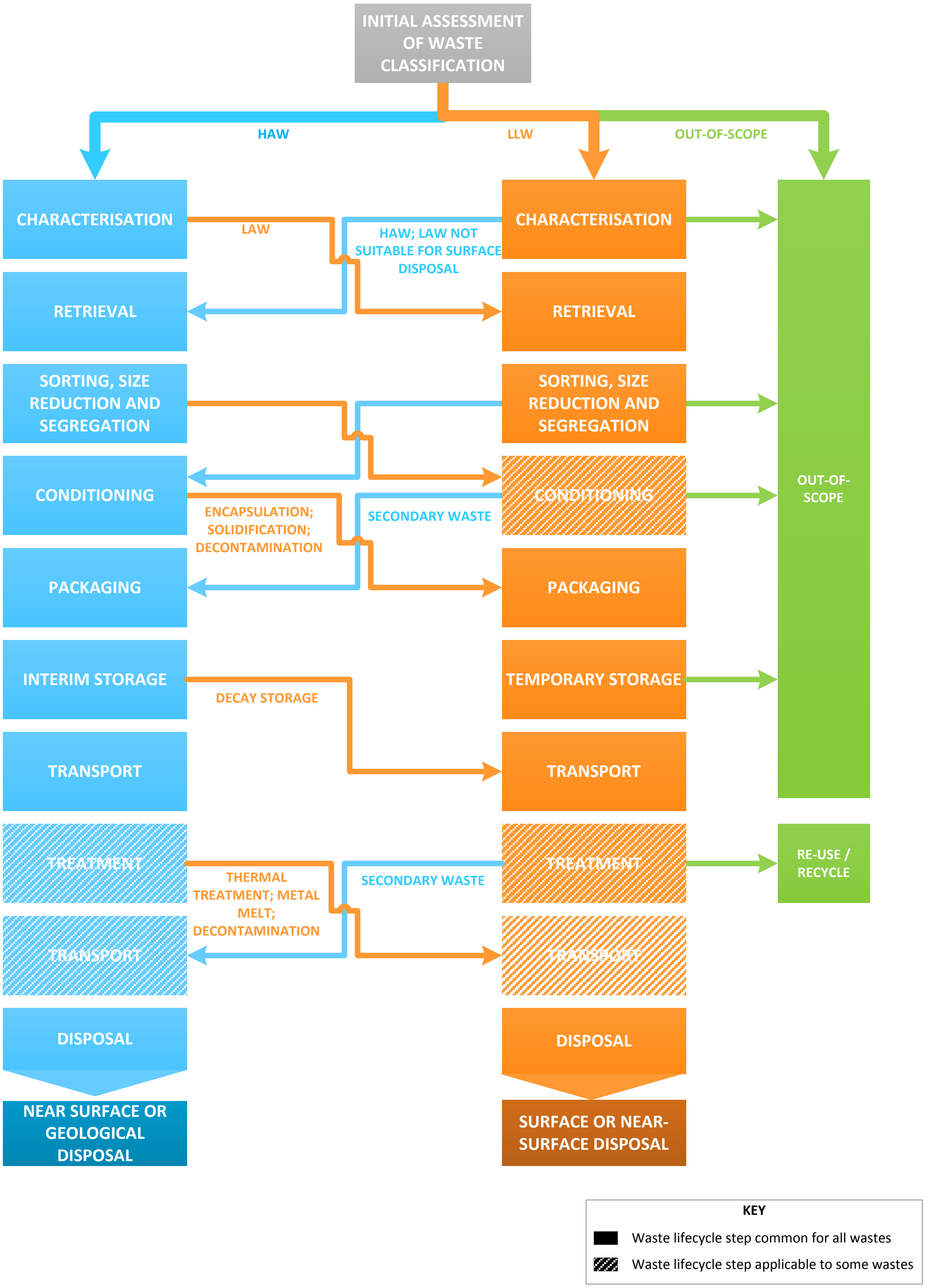
The “Waste Journey” and Indicative Timescales

1.24 The overall management of UK radioactive waste is summarised in Figure 1-2. This depicts the UK “waste journey”. LLW (including VLLW) is subject to various types of processing before being sentenced for disposal or being cleared for recycling. HAW is processed to make it suitable for both interim storage and disposal before being stored prior to emplacement in a GDF. Vitrified HLW and SNF is stored pending further encapsulation optimised for the final GDF design.

1.25 The management of the various waste classes may be characterised as follows:

- LLW and VLLW: processing to minimise the mass and the volume of waste requiring disposal (in line with the UK’s waste hierarchy - see Figure 2-1);
- HAW: retrieval and processing of raw wastes to enable passive interim storage followed by disposal to a GDF. Alternatively in Scotland ILW and some LLW is sent instead to a near-surface disposal facility when it becomes available. Vitrified HLW will require some form of additional packaging to provide additional containment for disposal; and,
- SNF: reprocessing or storage (wet or dry) at the site of production or Sellafield pending the availability of a GDF. Like vitrified HLW, SNF will require some form of additional packaging to provide additional containment for disposal.

Figure 1-2 UK "Waste Journey" from Generation to Disposal



Chapter 2 Policy, Strategy and Legal & Regulatory Framework

UK Transparency Policy and Processes

2.1 The UK Government and Devolved Administrations are committed to the principles of openness and transparency and recognise the fundamental importance of effective communication with workers and the general public. This commitment includes actively seeking the views of members of the public on new or changing Government policies by providing opportunities for stakeholder meetings or fora and/or to respond to public consultations where considered appropriate. Guidance on the principles that Government Departments and other public bodies should adopt for engaging stakeholders when developing policy and legislation is available at: https://www.gov.uk/government/publications/consultation-principles-guidance. Government takes responses received during a consultation into consideration when making related decisions.

2.2 The UK Government's policies and strategies on spent fuel and radioactive waste management are available from the UK Government website, as are the other various publications on this topic (https://www.gov.uk/government/publications). Advice to Government from independent advisory committees such as CoRWM is also made publicly available. The UK's Inventory, which is published on a triennial basis on the NDA's website, provides information in a format that is accessible to the non-specialist (http://www.nda.gov.uk/ukinventory).

2.3 Opportunities for public participation in decision-making related to spent fuel and radioactive waste management are part of a range of regulatory provisions, with key examples outlined in the following paragraphs.

Public information and participation regimes

2.4 Under the Freedom of Information Act 2000, the Environmental Information Regulations 2004, the Freedom of Information (Scotland) Act 2002 and the Environmental Information (Scotland) Regulations 2004, members of the public have the right to request information held by public bodies (subject to considerations such as national security and commercial sensitivity), including all the regulators of the UK's nuclear and non-nuclear industry and the NDA. The Aarhus Convention and EU Directive 2003/4/EC on public access to environmental information are implemented in part in the UK via the various environmental information regulations.

2.5 The UK has implemented the requirements for public participation in decision-making established under the Aarhus Convention, and reflected in EU Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment ("the EIA Directive") via a range of legislative measures including the Town and Country Planning (Environmental Impact Assessment)(England and Wales) Regulations 1999, the Town and Country Planning (Environmental Impact Assessment) Regulations 2011 and the Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2011. Proposals for new nuclear power stations and installations for the processing, storage or disposal of spent fuel and radioactive waste are capable of being EIA development. Applications for planning consent for EIA development, and their accompanying environmental statements, are subject to publication and consultation requirements that provide opportunities for public participation. The regulatory provisions outlined in this paragraph also require transboundary consultation in certain circumstances in line with the Espoo Convention.

2.6 In addition, the EIADR99 (as amended) requires an assessment of the environmental impact of decommissioning a nuclear power station and the submission of an environmental statement, with associated public consultation, prior to ONR granting consent.

2.7 Opportunities for public participation are also comprised in processes relating to:

- particular plans and programmes and their associated environmental reports in accordance with the Environmental Assessment of Plans and Programmes Regulations 2004 ("SEA Regulations"), which implement Directive 2011/92/EU (on the assessment of the effects of certain plans and programmes on the environment). The SEA Regulations also require transboundary consultation in certain circumstances in line with the Espoo Convention; and,

- appropriate assessments prepared for a relevant plan or project in line with the Conservation of Habitats and Species Regulations 2010 ("Habitats Regulations") which implement Directive 92/43/EEC (on the conservation of natural habitats and of wild fauna and flora).

2.8 Under the Planning Act 2008, the UK Government can designate national policy statements (NPSs) which provide the policy framework that must be taken into account in decisions on whether to give consent to specified kinds of development. Before the UK Government designates an NPS, it must undertake an Appraisal of Sustainability (AoS), which is an overall assessment of sustainability that includes potential social, economic and environmental impacts, and may also include the assessment requirements in the SEA and Habitat Regulations. Opportunities for public participation are provided within the overall process for designation of an NPS. In 2011, the then UK

Government designated a National Policy Statement for Nuclear Power Generation , and in the 2014 White Paper ‘Implementing Geological Disposal’ outlined the UK Government’s intention to designate a generic NPS in respect of GDFs in England.

2.9 The construction of new nuclear power stations, geological disposal facilities for radioactive waste, and deep boreholes to determine the suitability of sites for geological disposal facilities are ‘nationally significant infrastructure projects’ (NSIPs) under the Planning Act 2008. Proposals for an NSIP are considered by the Planning Inspectorate, which makes recommendations to the relevant Secretary of State on whether to grant or refuse development consent.

2.10 Prior to making an application, the applicant for consent for an NSIP must undertake consultation with local communities, local authorities, statutory bodies and other interested stakeholders. The Infrastructure Planning (Environmental Impact Assessment) Regulations 2009 provide for more specific implementation of the EIA Directive in relation to NSIPs, and impose obligations to ensure that those consulted as part of the pre-application process required by the Planning Act 2008 are informed that the development is EIA development and how they can obtain and comment on the EIA.

Specific regimes

2.11 The UK’s regulatory regime also comprises legislation that requires the NDA and regulators to provide the public with information on particular aspects of their activities in regards to spent fuel and radioactive waste management. This includes:

- The Energy Act 2004 places obligations on NDA to consult widely with regard to its strategy and annual plans, and to publish the resulting approved documents;
- EPR10 (England and Wales) and RSA93 (Scotland and Northern Ireland) require the UK’s environmental regulators to maintain public registers and provide information relating to environmental permitting, and undertake formal consultations on major regulatory decisions;
- The Energy Act 2013 requires ONR to publish strategic level data on its regulatory activities; and,
- REPPIR01 establishes a framework of emergency preparedness measures to ensure that members of the public are informed in advance about what to do in the event of a radiation emergency, and are provided with information if a radiation emergency occurs.

2.12 There are also a range of regulatory requirements to ensure workers are provided with information. For example:

- The Health and Safety at Work etc. Act 1974 and regulations made under that Act (such as the Management of Health and Safety at Work Regulations 1999) requires training of employees by employers, and the provision of information to employees concerning the: risks to their health and safety; preventive and protective measures; procedures necessary in the event of serious or imminent danger; and persons nominated to implement evacuation procedures. In addition, every employer has a duty to give information to persons who are not employees about the way in which the undertaking is conducted to the extent that it may affect their health and safety.

- The Ionising Radiation Regulations 1999 require that information, instruction and training is given to workers by relevant employers regarding the risks to health created by exposure to ionising radiation, the precautions that should be taken, and the importance of complying with regulatory requirements.

- The HASS Regulations (Scotland and Northern Ireland) and EPR10 (England and Wales) require the provision of information and training to workers in order to inform them of the precautionary measures required when dealing with HASS, including appropriate procedures for handling orphan sources.

Main Policy Principles

2.13 SNF and radioactive waste must be properly managed. Various UK Government and Devolved Administration policies on radioactive waste management [Ref 5] are therefore based on the same basic principles that apply to the environment and, in particular, to sustainable development [Ref 6]. Waste is consequently required to be managed and disposed of in ways which protect the public, workforce and the environment both now and in the future: i.e. that management aims to process wastes into a passive form and to take into account the impact of today's activities on future generations.

2.14 Within this approach, the UK Government and Devolved Administrations maintain and continue to develop policies and regulatory frameworks which ensure that radioactive waste:

- is not unnecessarily created in accordance with the waste hierarchy (Figure 2-1);

- is safely and appropriately managed and treated; and

- is then safely disposed of at appropriate times and in appropriate ways.

2.15 Producers and owners of radioactive waste bear the cost of managing and disposing of their waste and are responsible for developing their own waste management plans, ensuring that:

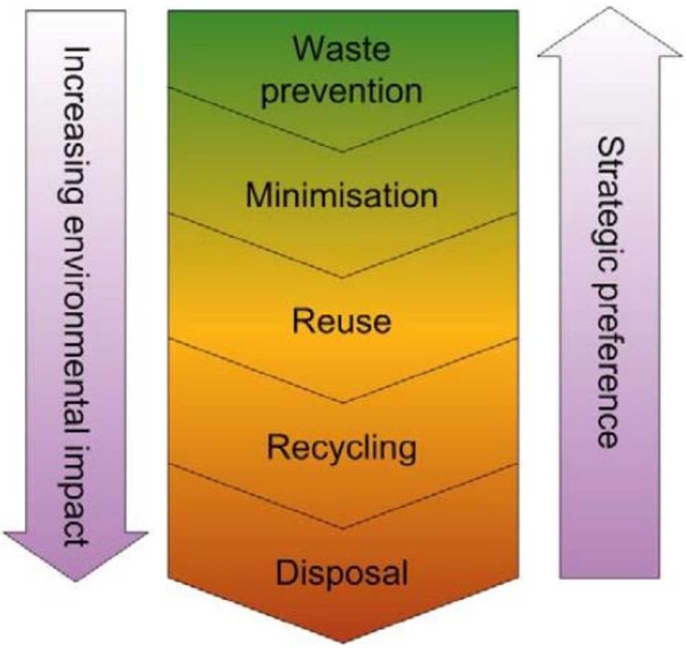
- they do not create waste management issues that cannot be safely managed using current techniques, or techniques which could be derived from current lines of development;

- where it is practical and cost-effective to do so, they characterise and segregate waste on the basis of physical and chemical properties, and store it in accordance with the principles of passive safety [5]; and,

- they undertake strategic planning, including the development of programmes for the disposal of waste accumulated at nuclear sites within an appropriate timescale and for the decommissioning of redundant plant and facilities.

2.16 The ongoing implementation of these radioactive waste management policies is seen in the progress made towards decommissioning of redundant nuclear facilities and continuing efforts to update and improve the site selection process for a GDF.

Figure 2-1 Waste hierarchy from the UK LLW waste strategy [Ref 7]



UK Policy for Low Level Waste

2.17 In March 2007 the UK Government and Devolved Administrations published a joint policy for the long term management of solid LLW in the UK [Ref 8]. Forecasts produced in this publication suggested that the total potential capacity of the LLWR could be reached by 2129 if this remained the single approach to LLW management. This was contingent on the waste hierarchy (Figure 2-1) being adhered to, whereby the LLWR was reserved solely for those wastes which were not suitable for treatment or disposal elsewhere.

2.18 The 2007 Policy [Ref 8] therefore called for the NDA to develop a UK nuclear industry-wide LLW strategy, to optimise the use of the LLWR and to make the NDA's LLW management facilities available to other users where appropriate and practical; this includes institutional waste producers. The policy calls for three strategies to be developed for: (i) nuclear industry LLW, (ii) non-nuclear industry LLW and (iii) naturally occurring radioactive material (NORM). The policy provides a management framework for LLW and recognises that, while the UK LLW management system is mature, opportunities exist for improvements and greater efficiency.

UK Policy for Higher Activity Waste (HAW)

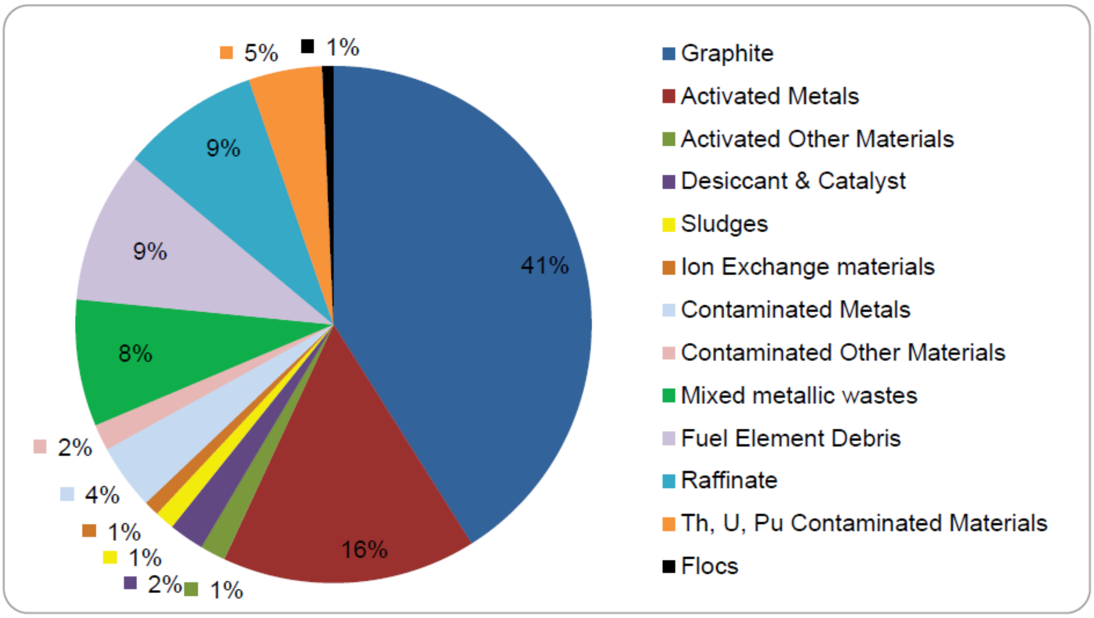
2.19 UK Government and Northern Ireland Policy for HAW is set out in the 2014 White Paper "Implementing Geological Disposal" [Ref 9]. This commits to the packaging of radioactive waste followed by safe and secure interim storage until such time as a GDF becomes available. It also commits to a process for identifying and selecting potential sites for a GDF based on working in partnership with willing communities, beginning with several years of work, led by UK Government and its delivery bodies. This process will provide information to the public in relation to:

- the land-use planning process to be applied to any GDF development,
- the national geological screening based on the role of geology in supporting a GDF safety case; and,
- develop detailed processes for local community representation and decision making, including a final test of public support prior to any decision to proceed with GDF development at a given location.

2.20 The Welsh Government has confirmed a policy for the geological disposal of HAW [Ref 10], and for spent fuel and other nuclear materials which may be declared as waste as part of a joint programme with England and Northern Ireland. The Welsh Government is currently consulting on proposals for engaging with potential volunteer host communities. The Welsh Government supports the packaging of radioactive waste followed by safe and secure interim storage until such time as a geological disposal facility becomes available. The Welsh Government also supports research into other management and disposal options which may offer advantages, in the future, for part of the UK Inventory.

2.21 The Scottish Government policy is that long-term management of higher activity radioactive waste should be in near surface facilities. Facilities should be located as near to the site where the waste is produced as possible. Developers will need to demonstrate how the facilities will be monitored and how waste packages, or waste could be retrieved. All long-term waste management options will be subject to robust regulatory requirements.

2.22 The HAW inventory in Scotland differs significantly from that in England and Wales, and the Scottish Government published its HAW policy in 2011 [Ref 11]. As set out in sections 2.02 and 2.03 of Scotland's HAW policy, it applies to ILW and certain categories of LLW. It does not apply to HLW, as there is no HLW in Scotland, or to SNF (which is covered by UK Government policy as set out below). A draft strategy to support the implementation of the Scottish Government HAW policy was published in 2015. Figure 2 in the draft strategy includes estimated volumes of packaged higher activity radioactive waste arising in Scotland (http://www.gov.scot/Resource/0046/00464771.pdf).



UK Policy for Spent Nuclear Fuel (SNF)

2.23 The current UK Government policy for managing SNF is a matter for the commercial judgement of its owners, subject to meeting the necessary regulatory requirements. However, in 2012 the Government made a clear decision to cease reprocessing in THORP (Thermal Oxide Reprocessing Plant). In the next five years we expect that the THORP and Magnox reprocessing plants will complete their committed reprocessing programmes. This policy applies across all parts of the UK.

2.24 Spent fuel from civil reactors can be reprocessed to produce separated plutonium and uranium products and HLW, ILW, LLW & VLLW as waste by-products. As described in Chapter 7, two reprocessing plants – for uranium metal and oxide fuel respectively - are currently operational at Sellafield. Both are scheduled to close by the end of the decade.

2.25 Currently all spent Magnox fuel and AGR fuel is sent to Sellafield for storage and/or reprocessing. Reprocessing is currently the only recognised way to manage Magnox fuel. Some of the spent fuel from the existing UK AGR power stations and all of the spent fuel from Sizewell B PWR are not currently destined for reprocessing. In the absence of any new commercial proposals for reprocessing, these fuels will be interim-stored pending direct disposal to a GDF.

2.26 In considering reprocessing in the context of nuclear new build, the 2008 White Paper 'Meeting the Energy Challenge: The Future of Nuclear Power' [Ref 12] stated that, in the absence of any proposals from industry, any new nuclear power stations that might be built in the UK should proceed on the basis that spent fuel will not be reprocessed and that plans for, and financing of, waste management should go forward on this basis. If such proposals were to come forward in the future, they would be considered on their merits and consulted upon.

2.27 In 2013, the NDA published its preferred option to transport nuclear material from Dounreay to Sellafield [Ref 13]. The materials involved include unirradiated plutonium and high enriched uranium bearing fuels. All transports are subject to regulation by the Office for Nuclear Regulation.

Strategy Development

2.28 As indicated in the next chapter, most of the radioactive waste that exists in the UK is owned by the NDA, which is required to develop a strategy for decommissioning and radioactive waste management across its estate. The Strategy is developed in consultation with stakeholders including the Devolved Administrations. The NDA, on behalf of DECC, oversees the decommissioning strategies, plans and costs of the main UK nuclear operator, EDFE.

2.29 The NDA strategy is delivered through the SLCs and is incorporated into their Site Integrated Waste Strategies and Lifetime Plans. For HAW these are founded on retrieval, treatment, conditioning and packaging. This is followed by interim storage until suitable disposal facilities are available. For LLW these are founded on retrieval, conditioning, packaging, then treatment and/or disposal. The NDA seeks to integrate this work across the NDA estate by looking for opportunities for improved cooperation and coordination between sites through, for example, use of shared long-term storage facilities.

2.30 The NDA is preparing an update to its integrated waste management strategic theme within the overall NDA Strategy (due to be consulted on in September 2015 before it is published) , which will continue to drive the estate wide optimisation of waste management and the effective implementation of the waste hierarchy so as to reduce risk (programme, cost, etc). Most of the opportunities centre on improvements to the current strategy, with an emphasis on effective use of the waste hierarchy so that, for example, good use may be made of existing and planned disposal facilities.

2.31 Chapters 4 to 8 of this document present a description of the UK radioactive waste management strategy as it applies to the various categories of waste and SNF. The three separate components of the LLW strategy are introduced below.

UK Strategy for Nuclear Industry Low Level Waste

2.32 The LLW policy [Ref 8] requires dedicated strategies to be developed for nuclear industry LLW, non-nuclear industry LLW and NORM. The resulting Strategy for Solid LLW from the Nuclear Industry [Ref 7] sets the application of the waste hierarchy at its core and identifies methodologies for its application throughout the industry. As a result, a range of alternate treatment and disposal routes have been established and are in use by the nuclear industry to treat and/or dispose of its VLLW and LLW. LLW Repository Ltd has the responsibility for integrating and optimising the management of LLW from the nuclear industry nationally.

UK Strategy for Non-Nuclear Industry Radioactive Wastes

2.33 The strategy for non-nuclear industry radioactive wastes [Ref 14] recognises that most of the waste is either exempt or LLW for which disposal routes exist. Users are required to ensure that these routes are employed. It is a condition of use of high-activity sealed sources (HASS) that licensees make financial provision for disposal (see paragraph 10.15). The small amounts of waste that cannot be disposed are placed in storage facilities operated under contract from the NDA at Sellafield or Harwell. Here they may decay to radioactivity levels that allow near-surface disposal or else they are kept in storage pending the availability of a GDF.

UK Strategy for Management of Naturally Occurring Radioactive Material (NORM) waste

2.34 The strategy of the UK Government and the devolved administrations is that, as with other types of LLW, NORM waste should be managed sustainably, efficiently and in line with the principles of the waste hierarchy. This requires a policy framework that enables and encourages waste producers to avoid unnecessary waste production and to manage arisings in an environmentally appropriate way. This is important to prevent unnecessary costs and delays to decommissioning of North Sea oil infrastructure and in protecting the environment when constructing new unconventional oil and gas developments. It is also crucial to enable the radioactive waste management supply chain to invest appropriately in order to avoid a capacity shortfall [Ref 15].

2.35 To achieve this, the strategy aims to stimulate investment in the waste management supply chain, principally by (i) reforming the regulatory framework to ensure it is clear, coherent and effective; (ii) encouraging the development of a robust and efficient market for NORM waste management; and, (iii) supporting efforts by waste producers and the waste management supply chain to generate better data and information about current and future NORM waste arisings [Ref 15].

National Regulatory Framework

2.36 There are two principal strands to the UK legislative and regulatory framework relevant to the 2011 Directive, and an overview of these is provided in the following paragraphs. More detail on the national framework as it relates to particular aspects of the National Programme is set out in the relevant parts of this document. Further detail on the national framework as it relates to Article 5 of the 2011 Directive is set out in the UK's National Report on implementation of the Directive. This section therefore gives a high level overview of the two principal strands.

2.37 The first strand addresses nuclear safety and occupational radiation protection aspects of spent fuel and radioactive waste management on nuclear sites, and is primarily comprised in the Health and Safety at Work (etc.) Act 1974 (HSWA) and the Energy Act 2013, together with associated provisions in the Ionising Radiation Regulations 1999 and those parts of the Nuclear Installations Act 1965 (NIA65) that concern licensing and safety.

2.38 The second strand addresses environmental protection and public exposure to radioactive substances in the environment and is expressed through controls on the keeping, use and disposal of radioactive substances on nuclear sites and elsewhere. In this context, disposals include radioactive discharges and radioactive substances including radioactive wastes. This is addressed through the Radioactive Substances Act 1993 (RSA93) in Scotland and Northern Ireland. For England and Wales the provisions of RSA93 were incorporated into Schedule 23 of the Environmental Permitting (England and Wales) Regulations 2010 (EPR10) [Ref 2] in April 2010.

2.39 The principal regulatory authorities are:

- Office for Nuclear Regulation (UK)

The Energy Act 2013 provided for the creation of ONR as an independent, statutory regulator of nuclear safety, security, and conventional health and safety at nuclear sites. The ONR came into being as a Public Corporation on 1 April 2014.

- Environment Agency (England)

The Environment Agency is an executive non-departmental public body of the Department for Environment, Food & Rural Affairs. It was established by the Environment Act 1995 (EA95). It has the responsibility for implementing and enforcing environmental legislation and the provisions of the EPR10.

- Natural Resources Wales (Wales)

Natural Resources Wales (NRW) was established in 2013 to take over the functions of the Countryside Council for Wales together with the Welsh operations of the Environment Agency and the Forestry Commission. NRW thus became the relevant statutory body for issuing permits, permit compliance and enforcement under EPR10 as well as other aspects of radioactive substances regulation in Wales.

- Scottish Environment Protection Agency (Scotland)

The Scottish Environment Protection Agency (SEPA) is a non-departmental public body, accountable through Scottish ministers to the Scottish Parliament. It was established by EA95 and has the responsibility for implementing and enforcing environmental legislation including the provisions of the RSA93.

- Northern Ireland Environment Agency (Northern Ireland)

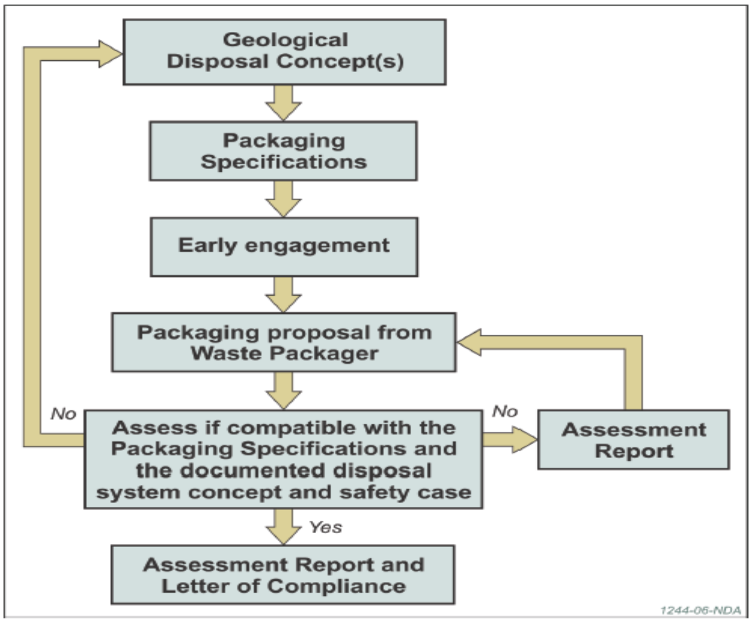
The Northern Ireland Environment Agency (NIEA) is an Agency within the Northern Ireland Department of Environment. Within the Agency, the Industrial Pollution and Radiochemical Inspectorate (IPRI) is responsible for implementing and enforcing the provisions of the RSA93.

Disposability Assessment Process

2.40 Regulatory approval for the conditioning of HAW for storage and disposal may consider the submission of a suitable Radioactive Waste Management Case (RWMC) [Refs 16, 17]. An important element of the RWMC for HAW is evidence that the conditioned waste will meet the anticipated waste acceptance criteria for a GDF. Radioactive Waste Management Limited (RWM)[3] provides such evidence by undertaking disposability assessments of operators' waste packaging proposals and, if these are acceptable, it issues Letters of Compliance (LoC) with supporting assessment reports [Ref 18] (Figure 2-2). The disposability assessment process and issuing of LoC are deemed to be applicable to geological disposal concepts and long-term storage of waste. Disposability assessment and the provision of packaging advice by RWM are subject to regulatory inspection.

[3] The wholly owned subsidiary of the NDA that is responsible for development of a geological disposal facility.

Figure 2-2 Disposability Assessment Process



Post-closure Institutional Control and Knowledge Preservation

2.41 If an environmental safety case claims a facility will be under active institutional control for some time after closure, the Guidance on Requirements for Authorisation (GRA) requires the operator to provide evidence that the proposed arrangements will be reliably implemented. Any claims placed on active institutional control need to be supported by detailed forward planning and a demonstration of funding. The GRA indicates, among other things, that:

- the developer/operator will need to show that the proposed measures are adequate and can be relied upon to be implemented as planned. Where a period of active institutional control is invoked, it should be supported by detailed forward planning of organisational arrangements (e.g. continued management, staffing and site security) and a suitable demonstration of funding arrangements;

- active institutional control should include site surveillance, remedial work as needed, environmental monitoring, control of land use and arrangements for the preservation of records. Guidance is given on the type of records that should be preserved; and,

- a claim for active institutional control lasting longer than 300 years is unlikely to be accepted by the environmental regulators.

Chapter 3 UK Radioactive Waste and Materials Inventory

About the Inventory

General

3.1 The UK produces a national inventory of radioactive waste and materials every three years. It provides in the public domain a snapshot of radioactive wastes and materials that were in stock at a specific point in time (called the 'stock date') and estimates of future waste arisings.

3.2 The 2013 Radioactive Waste Inventory (the '2013 Inventory') [Ref 19] was published in February 2014 and presented information based on a stock date of 1 April 2013. The next Inventory will be based on a stock date of 1 April 2016.

Estimates of Future Waste Arisings

3.3 Estimates of future radioactive waste arisings are projections made by the organisations that operate sites. These forecasts are based on assumptions about the nature, scale and timing of future operations and activities at their sites, known as the 'scenario' [Ref 19]. The estimates may change in future as plans and arrangements are developed. They may also change due to commercial, policy or funding reasons, or if improved data become available. Revisions can affect both the quantity and the timing of future arisings.

3.4 The 2013 Inventory does not include wastes from any proposed new nuclear power stations. Because these plants are still at the planning stage, the SNF and the waste that they will produce are not yet "committed". For that reason the waste does not appear in the current version of the UK Inventory. The arrangements that have been put in place for managing waste and SNF from the new build generators are, nevertheless, outlined in Chapter 8, and the UK Radioactive Waste Inventory will be updated on a regular basis as reactor designs and operating plans in relation to these new plants are confirmed.

Inventory for Disposal

3.5 For the purpose of planning and designing a GDF and to give host communities clarity with respect to the wastes that could be disposed there, the 2014 White Paper [Ref **Error! Bookmark not defined.**] defines the types of higher activity waste (and nuclear materials that could be declared as waste) which would comprise an "inventory for disposal" in a GDF. This includes civil and defence wastes (and which contain HAW), SNF that will not be reprocessed, including that from potential new nuclear build, (up to a yet to be defined amount), and uranium and plutonium that may be surplus to requirements. Some of these wastes and materials are not subject to reporting under the 2011

Directive and, while they may be mentioned in the White Paper and UK Inventory, their management is not discussed in this document.

Quantities of Radioactive Waste and Spent Nuclear Fuel

Radioactive waste

3.6 The 2013 UK Inventory contains data on over 1,300 waste streams. Further information is contained in the 2013 UK Inventory. [Ref 19]

Spent Nuclear Fuel

3.7 The UK's current stock of SNF consists mainly of Magnox, AGR and PWR fuels, but also includes smaller stocks of various irradiated experimental and research fuels. The UK also holds stocks of overseas-owned LWR fuel that is awaiting reprocessing[4]. Details on the volumes of spent fuel are also contained in the UK Inventory [Ref 19].

3.8 **Error! Reference source not found.** shows that the total mass of UK spent fuel at 1 April 2013 was about 9,600 tonnes of heavy metal (tHM), with estimated future arisings of about 2,200tHM.

3.9 It is planned that the stocks of Magnox, Steam Generating Heavy Water Reactor (SGHWR) fuels and other spent fuels at Sellafield, as well as DFR breeder material currently stored at Dounreay, will be reprocessed (apart from a small quantity that is unsuitable). It is also planned that future arisings of spent Magnox fuel will be reprocessed. A proportion of the fuel produced over the lifetime of the AGR stations will be reprocessed. Actual quantities of fuel to be reprocessed and/or stored are subject to contractual arrangements to be agreed between the NDA and its customers.

3.10 The Sizewell B PWR station is expected to generate about 1,000tHM spent fuel over its 40 year operating lifetime. It is anticipated that this fuel will not be reprocessed but will be stored pending disposal.

4 The UK has contracts with other countries to reprocess their spent fuel. All contracts signed since 1976 provide for the return of recovered uranium and plutonium and associated waste to the country of origin. UK policy allows “waste substitution” arrangements that ensure broad environmental neutrality to the UK.

Table 3-1: UK owned spent fuel - Mass in stocks and estimated for future arisings (tHM)

Location	Description	Stock at 1 April 2013 [1]		Estimated future arisings
		In reactor	In storage	
Sellafield	Magnox fuel		820	- [2]
	AGR fuel		2,900	- [3]
	SGHWR fuel		120	0
	WAGR fuel		28	0
	Other fuels		740 [4]	0
Dounreay	DFR breeder fuel	32	10	
	PFR		10	
	Other fuels		<1	0
Magnox power stations [5]	Magnox fuel	~2,500	~180	11
AGR & PWR power stations	AGR & PWR fuel [6]	~1,700	~510	~2,200
Others	Various		~10 [7]	0

(1) Fuel 'In reactor' is that in reactor cores; fuel 'In storage' has been removed from reactor cores to storage facilities.

(2) See Magnox power stations for future transfers of spent fuel to Sellafield.

(3) See AGR power stations for future transfers of spent fuel to Sellafield.

(4) Includes 1.6tHM DFR breeder fuel transferred from Dounreay.

(5) Includes Calder Hall on the Sellafield site.

(6) From data provided by EDF Energy and from best available public domain information.

(7) Comprises mainly low irradiated fuels including Zero Energy Breeder Reactor Assembly (ZEBRA) fuel as plutonium and natural uranium oxide plates on loan to Cadarache in France and other fuels at Harwell.

Chapter 4 Nuclear Industry Low Level Radioactive Waste

4.1 This chapter describes current and future radioactive waste management activities for VLLW and LLW. The description applies to all parts of the UK. Detail on the specific milestones and timescales are contained in the individual strategy documents - a summary of the key milestones and objectives is contained in Chapter 11.

4.2 Around 4.2 million m^3 of VLLW and LLW is forecast to arise until 2129, not including NORM wastes. 98% of this will be generated by the Site Licence Companies (SLCs) operating within the NDA estate. This may be compared with around one million m^3 of LLW already disposed.

Figure 4-1 Stacking Containers in Vault 8 at the LLW Repository (Courtesy LLW Repository Ltd)

Pre-disposal Treatment of LLW

4.3 Since the publication of the 2007 policy [8], increasing emphasis has been placed on waste avoidance, volume reduction and appropriate choice of disposal route so as to preserve, to the extent possible, the disposal capacity of the LLWR. The sub-sections that follow describe the various methods used to achieve this.

4.4 There will be a need for a number of bespoke routes to be opened for problematic wastes, which currently do not have a treatment or disposal route (for example the treatment of some oils or mercury). Industry is working collaboratively to develop bespoke routes for these problematic wastes and this work is supported by the research and development aspects of this programme.

Waste Avoidance

4.5 In conformance with the waste hierarchy (Figure 2-1), operating procedures and design principles for nuclear facilities aim to avoid the creation of radioactive waste. Practices include removing packaging before introducing materials into a radioactively contaminated area; having arrangements for tools to be retained within active areas to avoid constantly introducing new (clean) tools; and designing the layout of equipment so as to avoid placing it in a contaminated environment.

Waste Separation and Volume Reduction

4.6 All waste generators use a range of techniques to minimise the volume of radioactive waste which needs to be managed as VLLW or LLW, including:

- characterisation to facilitate appropriate sentencing of the waste;
- separating wastes before they become mixed or where they are mixed; either by segregating at source or in separate sort and segregation facilities. Many sites have facilities to segregate compactable from non-compactable waste; as well as segregating metal and combustible wastes to allow further treatment (see below);
- size reducing waste to enable more effective packing regimes (for example cutting up large items or shredding soft wastes);
- decontaminating wastes using a range of chemical and mechanical techniques; and,
- compacting waste.

4.7 LLW can consist of 'soft' wastes, such as paper, plastics, clothing and light metal items that are suitable for compaction. Low force compaction may be used by waste generators on bags of VLLW/LLW to reduce waste volumes prior to their being transported or disposed.

4.8 There are three UK high force compaction facilities available for UK consignors to use on waste for disposal at LLWR including one which forms part of the new LLW disposal facility adjacent to the Dounreay site (see para 4.19).

Recycling of Materials

4.9 Decontamination of metal waste may allow it to be reclassified as out of scope waste and sent for re-cycling. A number of waste generators have on-site decontamination facilities for metal (e.g. grit blasting) which can then be sent for recycling. Alternatively, waste may be size-reduced to allow it to be transported off site for further treatment - either surface decontamination (see **Error! Reference source not found.**) or re-melting. UK waste producers have access to commercial re-melting facilities located in Sweden, Germany (**Error! Reference source not found.**) and the USA. The overseas treatment of UK LLW is subject to authorisation under the Transfrontier Shipment of Radioactive Waste and Spent Fuel Regulations 2008 (Statutory Instrument 2008/3087).

Figure 4-2 Photograph of metallic waste prior to and following surface decontamination at the Studsvik UK MRF facility (Courtesy Studsvik UK))

Figure 4-3 Metal melting at the Siempelkamp facility, Germany (Courtesy Siemplekamp)

Volume Reduction by Incineration and Other Thermal Treatment Approaches

4.10 Within the UK, incineration is a widely used and mature waste treatment technology; and has been permitted for several years for treating suitable LLW. The process reduces waste volumes by up to 98% by burning combustible solid and liquid wastes, breaking down the reactive compounds and organics to create a stable homogenous waste form (ash) for disposal.

4.11 EDFE has access to an on-site incinerator and other commercial incinerators are available to the nuclear industry within the UK, as well as one facility in Sweden. These facilities have significant differences in the quantity, type of radioactivity and physical nature of the waste that they can accept and these are taken into account when determining which facility to use.

4.12 For UK incinerators, the waste is co-treated with other, non-radioactive waste and the ash is generally sent to landfill for disposal. Any LLW sent overseas for treatment is treated in a batch process and the resulting ash returned to the UK for disposal as LLW.

4.13 Other technologies for thermal treatment exist, such as pyrolysis and plasma arc processes. These are not currently used in the UK for treatment of LLW, but could form part of a solution to the management of some problematic wastes (as discussed in paragraph **Error! Reference source not found.**).

Disposal of VLLW/LLW

4.14 Until the mid-2000s the predominant route for the management of VLLW and LLW from the nuclear industry was through disposal to the LLWR in Cumbria. Between the 1950s and 1988 virtually all VLLW/LLW was disposed at LLWR by tumble tipping into clay lined trenches. Vault disposal operations at LLWR began in 1988 with the introduction of a cement-encapsulated monolithic waste form. Subsequently, high force compaction was introduced at Sellafield in 1995 as a mechanism to reduce the volume of the raw waste prior to disposal. The resultant waste pucks are encapsulated in ISO freight containers which are then disposed of in the vault (**Error! Reference source not found.**). Waste that cannot be compacted is placed directly into ISO freight containers and encapsulated in cement grout; historically some very large items have also been placed directly in the vault and grouted in situ.

4.15 The 2007 Policy [Ref 8] recognised that LLWR had limited capacity to receive the forecast future arisings and thus emphasised the need to minimise the amount of waste produced through the application of the waste hierarchy. As an alternative to disposal at LLWR, the policy did not preclude disposal at landfill facilities provided that necessary levels of safety can be demonstrated to the satisfaction of the environmental regulators.

4.16 Within the UK there are three landfill sites which are authorised to accept VLLW and some lower activity LLW (two of the sites are able to accept waste with activity concentration up to 200 Bq/g) and these routes are now well established. There are also other commercial landfill sites which receive small quantities of VLLW directly from the waste generators.

4.17 The LLWR in Cumbria currently has one vault (Vault 8) permitted for disposal and one vault (Vault 9) permitted for storage. Vault 8 has a very limited amount of authorised disposal capacity remaining. LLW Repository Ltd, which operates the site, has submitted a variation to their environmental permit to reflect their Environmental Safety Case (ESC); allowing LLW Repository Ltd to develop the site in accordance with national needs. LLW Repository Ltd will submit a planning application in Autumn 2015 for the capping of the trenches and existing vaults and the construction of three additional vaults. It is forecast that these additional vaults will provide disposal capacity until 2050.

4.18 As part of the ten-yearly periodic review of the Environmental Safety Case (ESC), consideration will be made of the requirement for additional vaults to provide disposal capacity for the forecast waste arisings to 2129; and applications for any additional vaults will follow in due course. While capping operations will be ongoing during the operational phase of the Repository, the ESC identifies a period of three years after the end of operations for final closure. There would then be a period of approximately 100 years when active institutional controls are in place (including a perimeter fence around the site, environmental monitoring and the management of the leachate system). This period of institutional control is in compliance with the Guidance on Requirements for Authorisation (GRA) [Ref **Error! Bookmark not defined.**]. The defined end state of the site is release from institutional control (at the end of the period of authorisation) for beneficial and sustainable community use.

Figure 4-4 ***LLWR Site. Previous trench disposals are located under the grassed area on the left; Vault 8 is almost full and shown bottom right; Vault 9 is indicated by the concrete pad*** **(Courtesy LLW Repository Ltd)**

4.19 The Dounreay site in northern Scotland has an engineered disposal facility to accept LLW from Dounreay. The facility will eventually have up to six vaults (with a maximum capacity of 175,000 m^3). Small LLW items are packed into drums and, where possible, high force compacted prior to being grouted into metal or concrete disposal containers. Some large LLW items will be disposed directly into the LLW vaults. Demolition LLW is packaged in bags (the waste is generally lightly contaminated building rubble) and these bags will be placed in the vault in layers, each layer having a granular in-fill over the top.

4.20 It is expected that the vaults will be full around 2028 at which time the temporary roof will be removed and the gaps between the vault walls and their excavations will be filled in. The interstitial space between containers and any large waste items within the LLW vaults will be filled with cement grout. All vaults will then be covered by a layer of concrete followed by a multi-layer cap over the whole facility. The cap will restore the original ground profile, reduce rainwater infiltration and deter inadvertent future intrusion. The site and surrounding environment will be controlled and monitored for approximately 300 years after closure to ensure that the facilities are not disrupted while the predominantly short-lived radioactivity decays.

Figure 4-5 Dounreay Site. Partial view of the site on the left showing the DFR sphere, near-surface disposal facility under construction on the right (Courtesy Dounreay and NDA)

(Ref: Dounreay/NDA photo library)

4.21 There have been some limited on-site disposals to pits and trenches at sites including Harwell, Springfields, Sellafield and Dounreay. Some of these facilities may require remediation prior to the sites reaching their end states, potentially generating some VLLW/LLW. This waste is not identified in the 2013 inventory because, while each individual SLC will determine the final location of the waste, the current intention is for the waste to remain where it is.

4.22 Historically Sellafield has disposed of VLLW/ HVLA (high volume low activity) excavated soil to the on-site South Landfill and Calder Landfill; both facilities are now non-operational. The Calder Landfill Extension Segregated Area (CLESA), which has a total capacity of 120,000 m^3, is currently being used for disposal of wastes from decommissioning and site clearance activities. Waste disposed to CLESA is primarily inert but the facility also accepts certain putrescible wastes unsuitable for disposal to LLWR (in accordance with its design intent). The current capacity of the CLESA site will not meet the total required capacity for such waste arisings and Sellafield is currently conducting a review of options to develop further on-site disposal capacity.

Chapter 5 Non-nuclear Industry Radioactive Waste

5.1 The Non-nuclear Industry Strategy [Ref 20] identifies the range of sectors which generate radioactive waste as hospitals; the pharmaceutical and biotechnology industries; universities, colleges and other research laboratories; veterinary medicine; and the oil and gas industry. The strategy [Ref 15] for management of bulk quantities of NORM arising from the oil and gas industries is described separately in Chapter 6.

5.2 Bulk NORM apart, these sectors generate relatively small volumes of LLW. They are able to access all of the routes used by the nuclear industry as described in this and previous Chapters and apply the principles of the waste hierarchy as illustrated in Figure 1-21.

Sealed Sources

Implementation of EC Directive 2003/122/EURATOM

5.3 Under the EPR10/ HASS Regulations [Ref 21], applicants for a permit/ authorisation involving high-activity sealed sources must show that adequate arrangements exist for the safe management of said sources. These include return to the supplier or transfer to a recognised storage facility and the associated financial provisions which must persist if the licence holder becomes insolvent or goes out of business. Acceptable arrangements for making such financial provision are also published.

5.4 The safe management of sources requires the provision of a ‘recognised installation’ for storage pending disposal. Such installations are usually located on major nuclear licenced sites but in some specific instances the LLWR is able to accept them. In either case, the storage facilities used need to have the necessary environmental permits.

5.5 On nuclear licensed sites, Licence Condition 4 (Restrictions on Nuclear Matter) ensures that the licensee carries out its responsibilities to control the entry and storage of nuclear matter (including sources) on the licensed site.

5.6 In all cases, Ionising Radiations Regulations 1999 Part VI applies, covering the arrangements for the control of radioactive substances, articles and equipment. Additionally, radioactive sealed sources that are sentenced for disposal are managed in line with the relevant policies and strategies for LLW or HAW.

Chapter 6 Naturally Occurring Radioactive Material (NORM)

6.1 In the UK, waste originating from specified 'NORM industrial activities' that contain concentrations of naturally occurring radionuclides exceeding levels set down in legislation is classified as radioactive waste. Depending on the specific NORM industrial activity in question, the radioactive waste may or may not fall within the scope of Directive 2011/70/EURATOM. However, as NORM wastes are classed as radioactive waste they are subject to the same regulatory framework as all other types of radioactive waste and no distinction is made between those that are within scope of Directive 2011/70/EURATOM and those that are not.

6.2 The UK strategy for the management of NORM waste [Ref 16] identifies the NORM industrial activities that are present in the UK that generate radioactive waste. The principal ones being: the oil and gas industry, the titanium dioxide industry, the steel production industry, and the china clay extraction industry. The strategy also contains information on how much NORM waste each industry currently generates and how it is managed.

6.3 The majority of NORM waste (that is not exempt from regulatory control due to its low radionuclide concentration) arises from the UK offshore oil and gas industry. This industry generates approximately 800 tonnes of solid NORM waste each year in the form of scale and sludge. These wastes are either discharged to sea, in line with domestic and international best practice, or sent on-shore for appropriate management. Those wastes that are sent on-shore are generally buried in landfill or due to the physical properties of some waste (e.g. high organic carbon content) they may be incinerated with the resulting ash going to landfill. Significant quantities of NORM waste may be produced during offshore platform decommissioning, however there is considerable uncertainty over both timing of decommissioning and the potential volumes of NORM waste that may arise. The objective of the UK NORM waste strategy is to ensure that secure, sustainable and resilient management options are available, for all NORM wastes.

Chapter 7 Higher Activity Waste (HAW)

Preparing for Storage and Disposal of HAW

7.1 In the UK, HAW consists of three main waste types. These are described in more detail below and in the UK Inventory [Ref 19].

7.2 Safe, passive storage is a regulatory requirement on nuclear sites throughout the UK and the decommissioning and waste management programme aims to (i) use risk assessment to prioritise activities, (ii) use the waste hierarchy to minimise the amount of waste produced, (iii) use the Disposability Assessment process (Figure 2-2) to provide assurance that packaged wastes are suitable for both passive storage and disposal and (iv) ensure that sufficient storage capacity exists to meet the need.

7.3 The rest of this sub-section details these waste retrieval and storage activities for the three types of HAW. Plans for disposal are provided separately under the headings “Framework for Disposal” and “Disposal Concepts”.

Vitrified HLW

7.4 Vitrified HLW is a residue of the reprocessing of SNF. In the UK it arises only at Sellafield and consists of fission product oxides dissolved in borosilicate glass. The molten glass is poured into 150 litre capacity stainless steel containers (Figure 7-1), allowed to solidify, seal welded and then sent to the Vitrified Product Store (Figure 7-1) where it will be held for at least 50 years to allow a significant proportion of the waste’s radioactivity to decay.

7.5 Chapter 8 outlines plans with respect to future reprocessing of the various fuel types. In summary, Magnox reprocessing and oxide reprocessing are expected to end between 2017 & 2020 and 2018 respectively. Some high active liquor (HAL) will remain in storage after these dates. However, the main operations producing vitrified HLW are not expected to end until around 2022 though vitrification will still be required in support of decommissioning and it is therefore anticipated to continue until circa 2030.

7.6 The Vitrified Product Store has enough capacity to accommodate all the vitrified HLW that will be generated by the SNF currently contracted to be reprocessed for UK customers. The UK Inventory indicates that the volume of HLW that will require disposal in the UK is 1080m^3; when packaged for disposal this will increase to 1410m^3.

Figure 7-1 Cut-away Vitrified HLW canister (Left) and Vitrified Product store, Sellafield (Right) (Courtesy Sellafield Ltd)

Waste Owned by Overseas Customers

7.7 Oxide fuel from overseas customers accounts for about half of the order book for Thermal Oxide Reprocessing Plant (THORP) reprocessing. For all overseas contracts signed since 1976, the vitrified HLW that is produced during the reprocessing of SNF is returned to customers as soon as practicable. “Substitution” agreements allow a radiologically equivalent additional amount of HLW to be sent in place of LLW and ILW. Returns of vitrified HLW to overseas customers started in January 2010 and are scheduled to continue for about ten years. It is planned that in total about 1,575 canisters of vitrified HLW (about 236m^3) will be returned to customers.

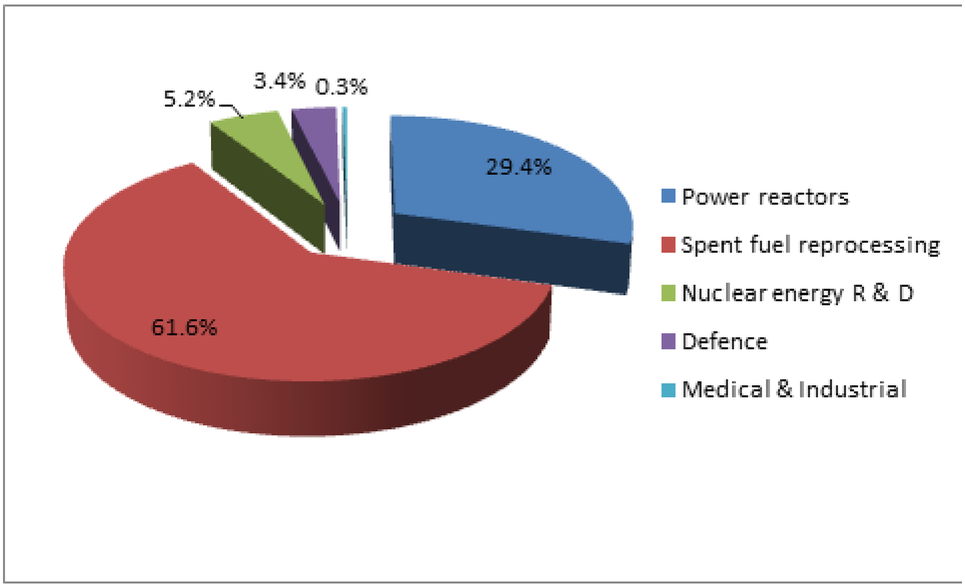
7.8 During the 1990s about 1,000 tonnes of test reactor fuel was reprocessed at Dounreay for customers in Belgium, Germany, the Netherlands and Australia. The contracts for this work require that the radioactive wastes produced be returned to the countries of origin within 25 years of reprocessing. The contracts are backed by inter-governmental letters. In 2012 the Scottish and UK Governments agreed in principle to allow waste substitution for these customers.

Intermediate-level Waste

General

7.9 The UK Inventory [Ref 19] shows that the total committed (i.e. current and future) reported volume of ILW was about 286,000 m^3. When packaged for disposal this will rise to 458,000 m^3. More than half of this (62%) comes from reprocessing and is located at Sellafield. Most of the remainder (30%) is at nuclear power plants (primarily the Magnox and AGR stations) with other significant amounts from nuclear energy research and development (Dounreay, Harwell etc). Medical and industrial sources comprise about 0.3% by volume (Figure 7-2).

Figure 7-2 Total intermediate-level waste volume broken down by business type (2013 Inventory). Total ILW reported volume is 286,000 cubic metres



7.10 Current ILW production is dominated by Sellafield fuel reprocessing wastes, most of which emit significant levels of radiation. Typically, these wastes are packaged inside steel drums and boxes known as ‘unshielded’ waste packages: UILW (U for unshielded). These are handled remotely inside shielded facilities (Figure 7-3) and transported in re-usable shielded transport containers. For the much larger volumes of ILW that will arise from future decommissioning the intensity of the emitted radiation will often be sufficiently low to allow for radiation shielding to be provided by its packaging alone. For the most part this will consist of thick walled concrete or cast iron containers. These are known as ‘shielded’ waste packages. They can be handled using standard industrial warehousing methods (‘contact-handled’) and transported without the need for over-packing. This waste is designated shielded ILW. The division into shielded and unshielded packages is important for the safety of operation and the design of both stores and disposal facilities.

ILW at Sellafield

7.11 A large number of operational ILW streams are generated as a result of spent fuel reprocessing. These include fuel cladding materials, sludges, ion exchange resins, plutonium contaminated materials (PCM), and solid waste from plant operations and maintenance. Most ILW is currently processed in encapsulation plants where waste is mixed with cement grout inside stainless steel drums (e.g. Figure 7-3). After washing and monitoring, the drums are transferred to purpose-built product stores. Graphite and stainless steel waste components from the dismantling of AGR fuel are size reduced, sorted and drummed. Contaminated equipment is loaded into large boxes that are also kept in a purpose-built store.

Figure 7-3 Magnox Waste Encapsulation Plant (Courtesy Sellafield Ltd) with Unshielded Waste Package

7.12 There are large quantities of historical wastes at Sellafield that were produced in the years before the waste plants were operating. These wastes are held in old facilities and include HAL, Magnox swarf and PCM. The HAL is being processed in the vitrification plant to reduce the volumes to buffer levels. An important ongoing objective is the retrieval of ILW from historical stores for conditioning followed by safe management through interim storage pending disposal. Programme activities are prioritised on the basis of risk assessments and, where necessary, remedial measures and a staged approach are adopted. Conditioning of ILW often consists of immobilisation with cement grout in stainless steel or concrete containers or, typically for lower density materials such as ion exchange resins, immobilisation with polymer in mild steel containers.

7.13 Interim storage facilities for ILW are designed to provide high confidence that packages will be retrievable, transportable and disposable at the end of the storage period. They also need to be capable of accepting many different package types. In line with UK and Scottish Policies (0) and the recommendations of the Committee on Radioactive Waste Management (CoRWM), the NDA aims to ensure that its strategy allows for safe and secure storage for a period of at least 100 years and has issued guidance to this effect [Ref 22]. At 1 April 2013 there were 54,129 packages of conditioned ILW in long-term storage facilities. About 88% of the ILW packages were at Sellafield.

7.14 The intention for all Sellafield ILW is to retrieve, condition and safely store it on-site until a GDF becomes available. To this end, new waste treatment plants are being constructed. In addition to the storage capabilities already mentioned, new ones will be added as needed.

ILW at Magnox Plants

7.15 Before sending fuel for reprocessing, most Magnox plants removed external fuel element components and stored them on site in purpose-built vaults. These wastes, known as fuel element debris, are classified as ILW. Other higher activity wastes, known as miscellaneous activated components (MAC) were removed from the reactor core and placed in shielded spaces near the reactor within the concrete biological shield. Other operational wastes (filters, desiccants, ion exchange resins etc) were placed in steel drums or accumulated in tanks.

7.16 All these wastes have accumulated in on-site facilities over the operational life of the plants. As part of the decommissioning programme, raw ILW currently stored on site has either been retrieved from old storage facilities, conditioned and moved to new storage facilities or is scheduled to under-go this process. Innovative solutions are being sought to reduce costs by, for example, reducing waste volumes and using disposable thick-walled ductile cast iron containers to avoid the need for cement encapsulation or additional shielding. The first of the Magnox ILW interim storage facilities went into operation at Bradwell in March 2014. Similar arrangements will be put in place at other Magnox plants in due course (Figure 7-4).

Figure 7-4 Interim Storage Facility for ILW (Courtesy Magnox Ltd)

7.17 Dismantling of the Magnox reactors will also produce ILW in the form of graphite and mild steel. The packaged volume of these decommissioning wastes is expected to be somewhat larger than that of the operational wastes. There is capacity within the NDA estate to deal with these wastes until a disposal route (via GDF) becomes available. The NDA have published a strategy paper on graphite waste management [Ref 23].

7.18 The relicensing of Research Sites Restoration Limited (RSRL), the former Site Licence Company (SLC) for the Harwell and Winfrith sites, has been completed and it now forms part of Magnox Limited (the new organisational structure was adopted as of 1st April 2015 [Ref 24).

ILW at other UK sites (Winfrith and Harwell)

7.19 In support of their decommissioning and site remediation programme, Harwell and Winfrith continue to package ILW for interim storage and future disposal. The decommissioning ILW generated and treated at Winfrith will be transported to the new store at Harwell along with waste from Culham. These waste transfers are part of NDA's storage strategy where nuclear materials will be transported from Harwell to the Sellafield site [Ref 25].

ILW at AGR Plants

7.20 Waste generation and treatment at the AGRs is broadly similar to the Magnox stations. Fuel element debris is produced by the dismantling of fuel stringers prior to the fuel's dispatch for reprocessing. Other waste items include items removed from the reactor core (e.g. control rods) and miscellaneous non-combustible and combustible wastes arising from normal operation and maintenance. Wastes arising from water treatment are accumulated in tanks. The expectation is that all these wastes will continue to accumulate at the power station sites until decommissioning starts when they will be conditioned for interim storage and disposal, where appropriate.

7.21 Compared to the operational wastes, the final dismantling of the AGR reactors will produce significantly greater volumes of ILW in the form of steel and graphite. There is capacity within the NDA estate to deal with these wastes until a disposal route (via GDF) becomes available. The NDA have published a strategy paper on graphite waste management [Ref 23].

ILW at the PWR Plant

7.22 The major waste types produced at the PWR (Sizewell B) are spent ion-exchange materials and evaporator concentrates from the treatment of water in the primary and secondary coolant circuits, fuel storage pond and liquid effluents. Other wastes arising from these water treatment systems are spent filter cartridges. All these wet wastes are stored in stainless steel tanks. Although no fuel dismantling takes place at the site, the dry wastes include various activated metal components from the reactor, such as control rods, burnable poison assemblies and in-core detectors. There are also arisings of miscellaneous contaminated items. Again, these wastes will continue to accumulate at the power station site until it ceases operation and decommissioning starts. The wastes will then be retrieved and conditioned (if needed) for interim storage and disposal. Relative to the ILW that will be produced by dismantling of the reactor, the volume of operational ILW is small.

ILW at Dounreay

7.23 The operation at Dounreay of an array of facilities including, until 1995, a fuel reprocessing plant has led to a wide range of radioactive wastes being stored on site. Waste arisings are processed/packaged and are then held on site in long-term storage facilities. Here, "long term" does not mean indefinite storage but it may mean waste is stored for many decades so that facilities are expected to have the capability to last for at least 300 years. During storage, stores will be maintained, refurbished or replaced as appropriate. The draft Scottish Government HAW Implementation Strategy recognises the importance of the availability of suitable disposal facilities to avoid the need to build more stores for retrieved waste.

Low-level Waste that is Unsuitable for Disposal in Existing LLW Facilities

7.24 As of April 2013, there exists around 17,000 m^3 of LLW with concentrations of long-lived radionuclides. This waste mostly arises at Sellafield and is mostly stored there, treated in the same way as ILW shielded packages, and will be sent for geological disposal.

7.25 Where such waste arises in Scotland, it is managed in accordance with Scotland's Higher Activity Waste Policy 2011 [Ref **Error! Bookmark not defined.**].

Geological Disposal

7.26 The 2014 White Paper [Ref 9] defines geological disposal by stating that it involves isolating radioactive waste deep inside a suitable rock volume to ensure that no harmful quantities of radioactivity ever reach the surface environment.

7.27 The NDA have published a Generic Disposal Facility Design document that is intended to provide information on the work undertaken on the development of a number of illustrative designs for a geological disposal facility in the UK. It also provides the basis for the safety assessment that underpins the disposal system safety case. This document forms part of a suit of documents and can be found at:

http://www.nda.gov.uk/publication/geological-disposal-generic-disposal-facility-designs-december-2010/

Framework for Site selection and Confirmation

7.28 Following a review of the practical implementation of previous geological disposal facility siting procedures, the UK Government and Northern Ireland Executive published a new White Paper in July 2014 [9]. This updates (and replaces in England and Northern Ireland) the previous 2008 White Paper but retains the clear commitment to working in partnership with willing communities to pursue the siting of a geological disposal facility. The Welsh Government has also confirmed a policy for the geological disposal of higher activity radioactive waste [10].

7.29 The 2014 White Paper, applicable in England and Northern Ireland, sets out a two year programme of initial actions that will be undertaken by the UK Government and by the developer (Radioactive Waste Management Limited) to help implement geological disposal. These initial actions, in the areas of national geological screening; national land use planning and working with communities, are designed to provide more information to communities in advance of formal discussions with the developer which will enable communities to engage in the process with more confidence. Early community investment payments will be made available to communities that engage with the developer early in the siting process and communities will have a right to withdraw at any stage of the siting process leading up to a test of public support. Formal discussions between interested communities and the developer will not begin, however, until the two year programme of initial actions is complete and the results available to all potentially interested parties.

7.30 Like the UK Government's approach, the Welsh Government strongly supports the principle of voluntarism in delivering geological disposal and considers that, in Wales geological disposal can only be delivered on a voluntary basis with the willing participation by potential communities in discussions which may lead to a decision by those communities to accept a geological disposal facility. As part of implementing its policy for the geological disposal of higher activity radioactive waste the Welsh Government has issued a consultation seeking responses on proposals for engaging with potential volunteer host communities. In this consultation the Welsh Government's preferred option is to adopt processes which will be compatible with the arrangements already put in place by the UK Government and the Northern Ireland Executive depending on the outcome of the consultation and providing that these arrangements are appropriate for Wales.

Chapter 8 Spent Nuclear Fuel (SNF) Management

8.1 For UK spent fuels, it is convenient to divide them into three groups: Magnox, oxide and exotic. All three are explained below.

8.2 The practices described here apply across England, Wales and Scotland. In relation to any new nuclear build, UK Government policy is that it should proceed on the basis that SNF will not be reprocessed and will, therefore, be stored pending disposal [Ref 12].

Magnox Fuel Reprocessing

8.3 Magnox reactors were the first generation of nuclear power producers in the UK. Magnox fuel is all metal and consists of rods of natural or slightly enriched uranium clad in a magnesium-based alloy (Figure 8-1). Responsibility for decommissioning the Magnox reactors was assigned to the NDA in 2005 and they are currently at different stages of de-fuelling and decommissioning.

8.4 All spent Magnox fuel is owned by the NDA and the management strategy is to reprocess it. The strategy is mature and well established having been in operation since 1964. It is, at present, the only accepted technology for managing spent Magnox fuel. To date, over 90% of the lifetime arisings of Magnox fuel have been reprocessed and there is now less than 3,000 tonnes remaining for reprocessing.

8.5 Delivery of the Magnox spent fuel strategy is managed through the Magnox Operating Programme (MOP) [Ref 26] which states that reprocessing of Magnox will be completed sometime between 2017 and 2020 [26]. The range of dates reflects likely upper and lower bounds of performance of the Magnox reprocessing plant.

8.6 In recognition of the risks associated with ensuring the availability of facilities required to continue reprocessing, three possible contingency options have been identified [Ref 27]:

- Extended dry storage of fuel which has not been wetted.
- Extended wet storage of fuel which has been wetted.
- Vacuum drying of any wetted fuel, followed by emplacement of the fuel inside containers for extended dry storage.

8.7 Each of these three options would be followed by conditioning to make the fuel suitable for geological disposal. The nature of this conditioning will be determined during the period of storage leading up to disposal.

Figure 8-1 Magnox fuel elements

Oxide Fuel

Reprocessing

8.8 Spent oxide fuel is currently received at Sellafield for pond storage pending reprocessing in THORP, which is a commercial facility offering reprocessing services to customers that include EDFE and overseas operators of light water reactors. Specifically, this fuel originates from:

- Advanced Gas-Cooled Reactors (AGR) operated by EDFE, formerly British Energy estate, in the UK (Figure 8-2); and,
- Various Light Water Reactors (LWR) operated by utilities around the world.

8.9 The NDA is contractually committed to receive and manage all of the spent fuel arising from the seven EDFE AGR power stations (14 reactors) in the UK; these power stations are due to operate to various dates to at least the mid-2020s.

8.10 The NDA carried out a comprehensive review and consultation [Refs 28,29] on its oxide fuel strategy, starting in 2010. Subsequently, it declared a ‘preferred option’ to cease THORP reprocessing operations in 2018, when its contractual commitments for reprocessing have been closed out, and then to interim store any outstanding oxide fuels, pending geological disposal [Ref 30].

8.11 In the case of oxide fuel reprocessed for overseas customers, extracted uranium and plutonium is to be returned to customers in line with contractual commitments. Also returned are the separated fission products in the form of vitrified HLW. Under the terms of the contracts an additional amount of vitrified HLW is sent to the customer to substitute for low- and intermediate-level reprocessing wastes retained in the UK.

Storage

AGR

8.12 Following the cessation of reprocessing, any remaining AGR spent fuel and all future arisings will remain in interim storage until a GDF becomes available. The amount of AGR spent fuel committed to interim storage is estimated to be several thousand tonnes, although the precise amounts will depend on the how long the AGR fleet remains in operation.

8.13 Interim wet storage of AGR fuel, which is clad in stainless steel, has been achieved for up to 25 years and the NDA's preferred option, published in 2012 [Ref 30], is to continue this practice. Sellafield Ltd is currently carrying out various activities to support the transition to wet interim storage when reprocessing ceases. These activities include, most notably, the preparation of a safety case to be submitted to nuclear regulators. The strategy [Ref 30] will be reviewed on an annual basis and, as a contingency, research and development will be conducted into drying and dry storage concepts for AGR fuel. Future strategic reviews, will consider the interim storage arrangements and any need to supplement them or develop alternative arrangements to facilitate disposal of the fuel to a GDF.

PWR

8.14 There is one PWR in the UK that is owned and operated by EDFE at the Sizewell B site, in the east of England. The Sizewell B reactor, which commenced operations in 1995, is expected to continue generating electricity until at least 2035. Spent nuclear fuel from Sizewell B is transferred to an at-reactor storage pond. However, this pond is not intended to accommodate the lifetime arisings of spent fuel from the reactor. An interim spent fuel storage facility, involving dry storage in Multi-Purpose Canisters, is currently being constructed at the Sizewell B site; this facility is expected to become operational in 2016. The Sizewell B dry store will provide capacity for all the spent fuel (approximately 1,200 tHM) produced over the lifetime of the power station and will support, subject to regulatory approval, a plant lifetime extension to approximately 2055. It will operate in a passive mode until fuel is retrieved, beginning around 2080, and transported over a 20-year period to a GDF [Ref 31]. International experience suggests that wet storage of Zircaloy-clad fuels for at least 100 years can be achieved and dry storage for considerably longer.

Figure 8-2 Receipt of AGR Fuel at Thorp

Figure 8-3 PWR fuel flask in Thorp

Nuclear New Build

8.15 The 2014 White Paper [Ref 9] includes new build SNF within the "inventory for disposal". In the 2008 White Paper "Meeting the Energy Challenge" [Ref 12], the UK Government concluded that any nuclear power stations that might be built in the UK should proceed on the basis that spent fuel will not be reprocessed. Assuming 16GW of new nuclear build by 2030 with a lifetime of 40 years, this could produce of the order of 17,000 tonnes of SNF. With 50 years' cooling this would be available for disposal around 2120.

8.16 In response to a request from the UK Government following its 2006 Energy Review, ONR and the environmental regulators developed the Generic Design Assessment (GDA) process [Ref 32]. This allows nuclear reactor design companies and would-be operators to request regulatory bodies to review and comment on their plans in advance of any construction work. Included in the GDA is an examination of how the operators will manage the spent fuel and radioactive waste arising from the new facility [Ref 32].

Fuel of Overseas Origin

8.17 In addition to AGR and PWR fuel there is now less than 150 tonnes of overseas origin fuels left to reprocess in THORP from an original volume of over 4,500 tonnes. It is likely that not all of the overseas origin fuel will be reprocessed and the NDA has estimated, at this time, that around 30 tonnes of overseas origin fuels may be uneconomic to reprocess in THORP or not possible to reprocess before THORP operations cease. For these, DECC published its response [33] to the public consultation on the management of overseas fuels and concluded that employing "virtual reprocessing" coupled with interim storage pending disposal is an acceptable alternative management route that the NDA can potentially utilise for these fuels. Virtual reprocessing would ensure that the UK does not become a net importer of nuclear waste by allocating a radiologically equivalent amount of waste and nuclear materials from existing stocks, as if these fuels had actually been reprocessed. Where practicable, the allocated waste and, depending on agreement with respect to their future management, the nuclear materials would then be exported to the customer as a substitute for their original materials.

"Exotic" fuels

8.18 There are approximately 500 tonnes of non-standard fuels, commonly referred to as 'exotics', in the UK. These fuels remain from earlier nuclear industry activities such as the development of research, experimental or prototype reactors. Although exotics often share the physical characteristics and properties of Magnox and oxide fuels, they are variable in both composition and enrichment; a substantial number are plutonium-based. There are four main types:

- Dounreay Fast Reactor breeder fuel;
- Prototype Fast Reactor driver fuel;

- Dragon High Temperature Reactor fuel; and,
- Steam Generating Heavy Water Reactor fuel.

8.19 Due to this diversity, a range of treatment options will need to be deployed. These will be evaluated through a lifecycle impact analysis that will consider such factors as hazard, risk reduction, commercial opportunity and liability, security and safeguards, resource utilisation and technology maturity. Treatment options will be underpinned through ongoing R&D activities and could include:

- immobilisation – encapsulation or dispersion of fuel in a matrix such as cement, ceramic, glass or polymer;
- stabilisation – treatment and packaging of the fuel to make it capable of long term passive storage prior to disposal in a GDF; and,
- reprocessing either in the UK or overseas as appropriate.

8.20 Specific proposals for the main exotic fuels are described below.

DFR Breeder Material

8.21 The Dounreay Fast Reactor (DFR) operated between 1958 and 1977 at the Dounreay site, in the north of Scotland. DFR contained "driver" fuel in the central part of the reactor core with a surrounding "blanket" of metallic uranium breeder material. The purpose of the blanket was to capture neutrons in order to produce plutonium, which could then be removed by reprocessing and used to make new fuel.

8.22 The driver fuel was reprocessed at Dounreay but the breeder material remains – some in storage and some still in the reactor. Recent re-examination of the various options indicates that the optimum solution for management of this fuel is reprocessing alongside spent Magnox fuel [Ref 34] at Sellafield. Accordingly, since 2012, DFR breeder material has been transferred from Dounreay to the Sellafield site for this purpose. All of the breeder material (44 tonnes in total) is due to be managed in this way and has been included in the MOP. There are, however, small amounts of breeder material which are likely to be 'out of specification' for reprocessing at Sellafield. The Dounreay and Sellafield nuclear site license companies, with support from the NDA, are currently investigating possible management options for this material.

Prototype Fast Reactor Spent Fuels

8.23 A 250MW(e) fast reactor, the Prototype Fast Reactor (PFR), was operated at Dounreay between 1974 and 1994 and approximately 15 tonnes of spent PFR fuel – mostly oxide and carbide with a smaller quantity of MOX – are in storage at the Dounreay site. It is planned to transfer this material to Sellafield for immobilisation and disposal or reprocessing [34]. The PFR oxide fuel is to be stored in stainless steel containers, within bottles in a Sellafield pond, while the carbide fuels are expected to be dry stored in casks. The transfers from Dounreay to Sellafield are due to start towards the end of this decade. Detailed design work, including the means of disposal, is ongoing.

'Dragon' High Temperature Reactor Fuel

8.24 The Dragon reactor was a 20 MW(th) high-temperature helium-cooled experimental reactor located at Winfrith that was operated from 1965 to 1975.

8.25 The properties of the Dragon reactor spent fuel vary significantly from other commercial and experimental fuels in that fuel elements are 60 mm diameter coated graphite spheres in which thousands of 1mm diameter fuel "kernels" are embedded. Many different fuel types were experimented upon including high- and low-enriched uranium dioxide and carbides, and oxides and carbides of thorium and plutonium [Ref 35]. The fuel has a high fissile inventory and was heavily irradiated. On decommissioning, the fuel was originally placed into mild steel spent fuel canisters and stored in the Dragon Fuel Store at Winfrith. It was then repackaged into stainless steel containers before being transferred from Winfrith to Harwell between 2002 and 2004, where it is currently stored dry.

8.26 In 2011, following a public consultation, the NDA concluded that the preferred option for Dragon fuel was to transfer it to the Sellafield site, to be encapsulated in cement in the Magnox Encapsulation Plant (MEP), a facility which is ordinarily used to encapsulate magnesium-based swarf removed from spent Magnox fuel prior to reprocessing [Ref 25]. Encapsulation of Dragon fuel in MEP is due to be complete by the end of the decade and, as with the standard MEP product, will result in a waste package that can be disposed as non-heat generating.

Steam Generating Heavy Water Reactor Fuel

8.27 A Steam Generating Heavy Water Reactor (SGHWR) – with a heavy water moderator, and a light water coolant – was operated at Winfrith between 1967 and 1990. The fuel is similar to that of a conventional LWR consisting of uranium dioxide pellets clad in Zircaloy. SGHWR oxide fuel has since been transferred to Sellafield, and is planned to be reprocessed in THORP in 2016. The resulting wastes will be similar to those already produced by THORP and will, therefore, be disposable to a GDF.

8.28 Other exotic fuels include highly-enriched uranium and carbide fuels; these may be irradiated or not. For these, research and development activities are ongoing with the aim of finding optimum solutions for their treatment, storage, transport and disposal.

Disposal of SNF

8.29 Disposal of SNF is covered in Chapter 7.

Chapter 9 Skills, Research, Development and Demonstration

Skills

9.1 The UK Government Nuclear Industrial Strategy [Ref 36] outlines the actions and approach needed to realise a vibrant, diverse and strategically cohesive nuclear sector. The Nuclear Energy Skills Alliance is a grouping of the key strategic skills bodies that is working to address the current and future skills needs of the UK nuclear programme. Contributing to this effort is the employers' organisation for skills, COGENT, and underpinning the whole is the national system for education in the sciences and engineering. The work is coordinated by the National Skills Academy for Nuclear.

9.2 The Energy Act 2004 charges the NDA with developing and maintaining appropriate skills and expertise for the decommissioning and clean-up of nuclear installations and sites. To this end, the NDA's Skills and Capability Strategy was launched in 2008 following a stakeholder consultation [Ref 37]. This makes clear that the day-to-day management of skills provision is delegated to the SLCs, while the NDA fulfils its obligations by providing oversight. The strategy aims to ensure that, across the NDA estate (including the SLCs), there are the skills and capability needed to carry out its mission safely and effectively.

9.3 Direct investment by the NDA has helped deliver major skills and training facilities across the UK. Alongside these capital projects, the NDA and the SLCs have developed a number of skills initiatives for nuclear graduates and apprentices. For example, a Nuclear Skills Passport scheme provides a more consistent approach to the management and transferability of qualifications, competencies and skills.

9.4 The 2008 NDA Skills and Capability Strategy was updated as the "People and Skills Strategy" in 2014 [Ref 38]; it places a greater emphasis on collaboration than formerly and provides a more focussed approach by identifying key areas for development and associated critical success factors. It aims, for example, to encompass resource planning across the NDA estate by removing barriers to workforce mobility, sharing good practice and introducing a collaborative approach to human resource issues between the NDA and SLCs.

9.5 On behalf of the Scottish Government, Skills Development Scotland (SDS) published an Energy Skills Investment Plan (SIP) [Ref 39] in 2015, to address skill shortage issues in the Scottish energy sector, including the nuclear sub-sector. The purpose of the SIP is to develop a framework for public and private sector investment to develop skills provision to meet industry needs. The Energy SIP includes initiatives to upskilling existing workforces and inspiring and preparing young people to develop careers in the energy sector. In developing the SIP, SDS sought the views of employer led bodies including the National Skills Academy for Nuclear.

9.6 More widely, the regulatory framework and authorities require companies holding nuclear licences to employ "suitable qualified and experienced persons" in key roles and to have in place appropriate arrangements for staff training.

Research, Development and Demonstration

Universities and the Research Councils

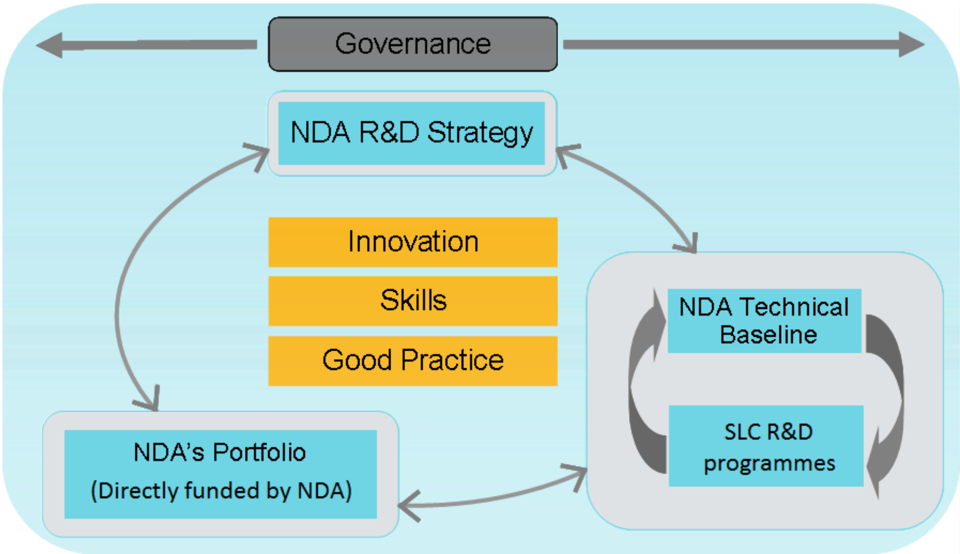
9.7 The UK Government funds academic research through seven Research Councils which invest around £3 billion per annum in research covering the full spectrum of academic disciplines. Research into various aspects of nuclear power and radioactive waste management is included within a number of disciplines. Several UK academic institutions have a high international profile with respect to radioactive waste processing and disposal.

Nuclear Decommissioning Authority

9.8 As required by the Energy Act 2004, Research and Development (R&D) in support of decommissioning and radioactive waste management is a supplemental responsibility of the NDA.

9.9 The NDA R&D strategy [Ref 40] aims to ensure that sufficient and appropriate R&D is carried out to deliver the mission; it is subject to stakeholder consultation. The strategy includes technical underpinning work carried out by the SLCs and R&D sponsored directly by the NDA. For example it ranges from technical development and optioneering studies, which underpin delivery of key decommissioning projects, to focussed research aimed at developing and maintaining key technical and engineering skills.

Figure 9-1 NDA Approach to Management of R&D (simplified from [40])



9.10 The NDA aims to cooperate with the Research Councils, universities, regulators and other organisations to identify synergies, avoid overlaps and take advantage of collaborative programmes and match-funding opportunities. Two bodies have been established to promote these exchanges: the NDA Research Board on Waste Management and Decommissioning and the Nuclear Waste Research Forum. The regulatory authorities also have the ability to request the SLCs to perform or to fund R&D to address specific issues.

National Nuclear Laboratory

9.11 The 2013 Nuclear Industrial Strategy (NIS) [Ref 36] restated the mission of the National Nuclear Laboratory and its support for the organisation advising on current and future commercial opportunities in the global nuclear market. The National Nuclear Laboratory is an entity owned by the UK Government with three key objectives to:

- take a lead role in national R&D programmes supporting the objectives in the NIS which includes capabilities (skills, facilities) development;
- act as a UK Government advisor on civil nuclear topics; and
- undertake R&D funded by customers in the UK and overseas (its role prior to 2013).

9.12 These objectives require NNL to make UK Government aware of any arising issues relevant to nuclear development or to UK Research and Development in general. NNL also promotes skills development through an in-house research programme.

Nuclear Innovation and Research Advisory Board

9.13 At the beginning of 2014 the UK Government established the Nuclear Innovation and Research Advisory Board (NIRAB) to provide information and advice on the priorities for UK nuclear innovation and options for better co-ordinating the UK nuclear research landscape. The first annual report was published in 2015 [Ref 41].

Chapter 10 Economic and Financial Considerations

10.1 The UK Government expects all nuclear operators to take the steps necessary to ensure that their work on decommissioning and radioactive waste management is adequately funded. The key players for existing wastes are the NDA and EDFE. For nuclear new build, the UK Government has issued guidance on the required funding arrangements for decommissioning and waste management [42] and, in 2008, established the Nuclear Liabilities Financing Assurance Board (NLFAB), an independent advisory non-departmental public body.

10.2 For the non-nuclear industry UK Government, the Devolved Administrations and environmental regulators have important roles to play in improving regulatory practice. The UK regulatory regime relating to planning provides the framework for ensuring that waste needs are planned for and that there are sufficient facilities in the right locations and of the right type to meet those needs. However, investment decisions over provision of facilities and disposal routes are ultimately for the market. Waste producers are responsible for their wastes, and should be planning for the effective management of waste as a part of good business practice. Effective implementation of UK non-nuclear radioactive waste strategies will lead to better information and data availability leading to a stronger market particularly for NORM waste management services, ensuring the UK is better able to deal with changes to the volumes of wastes produced by opening new waste facilities and preserving existing ones.

2013-16 Budgetary Settlement for the NDA

10.3 Funding for the NDA's activities comes directly from central UK Government, through its sponsoring Department, DECC. The NDA Business Plan[43] is the primary vehicle for securing the funds as well as setting out the proposed activities for the NDA estate. Receipts from commercial activities such as electricity generation and spent fuel management will reduce over time as operational facilities move into the decommissioning phase. The total planned expenditure is voted upon annually by the UK Parliament.

Private Nuclear Operators

10.4 The UK Government's restructuring of British Energy in 2005 created a new independent funding mechanism, the Nuclear Liabilities Fund. EDF, as the owner of the ex-BE estate, is obliged to make a schedule of regular payments into the NLF. The NLF then disburses its funds back to EDF in a controlled manner for use solely in discharging certain defined decommissioning and historic fuel related liabilities associated with the AGRs or Sizewell B. Checks have been put in place to ensure NLF monies can only be used for these purposes. The UK Government stands behind the NLF; NDA's role is to ensure that funds are disbursed appropriately and that EDFE's proposed strategies for the relevant liabilities align with that of the rest of the civil nuclear sector, which is owned by NDA and funded by the UK Government.

10.5 NDA also scrutinises plans for decommissioning and waste and cost estimates by new nuclear power plant developers submitted to DECC as part of their Funded Decommissioning Programmes (FDPs) (the funding arrangements are scrutinised by the Nuclear Liabilities Financing Assurance Board (NLFAB)[Ref [5]] and advises the Secretary of State on the robustness of these plans.

Nuclear Decommissioning Authority

10.6 The NDA calculates its provision annually based on the best estimate of the future costs of the decommissioning programme, which is expected to take until 2137 to complete, and reports these findings in the publication of the NDA Annual Report and Accounts [Ref 44].

10.7 The NDA also considers credible risks and opportunities which may increase or decrease the estimate of the cost of decommissioning, but which are deemed less probable than the best estimate. These include the variability in the cost of construction and operation of any future LLW, or Geological Disposal Facilities; consideration of options to accelerate the clean-up of legacy research sites; and the cost of new construction, decommissioning and post operational clean out work in the long term at Sellafield [Ref 44].

Funding of Geological Disposal

10.8 In order to ensure the provision for a future facility for the disposal of HAW, the GDF lifetime plan will be produced by Radioactive Waste Management Limited (RWM) as the developer. This is then used to provide an assessment of cost to NDA, which will in turn incorporate the cost assessments into its Annual Report and Accounts. However, other waste producers share the liability for the provision of a geological disposal facility, thus the NDA is not solely responsible for ensuring the full provision of a future facility. For example, as reported in the 2013-2014 Annual Report and Accounts, NDAs portion of liability to fund GDF is reported at £4,077m.

Funding of Decommissioning and Waste Management for New Nuclear Build

10.9 Under the Energy Act 2008, a prospective operator of a new nuclear plant is required to submit its plans for decommissioning and waste management in a Funded Decommissioning Programme (FDP).

[5] NLFAB is an advisory Non Departmental Public Body sponsored by DECC. Created in 2009 its purpose is to provide the Secretary of State with independent advice on the suitability of the funding element of a new nuclear operator's FDP.

Alongside this, it also needs to ensure it has secure financing arrangements in place to meet the full costs of decommissioning and its full share of waste management and disposal costs.

10.10 The NDA scrutinises the operator's proposed waste and decommissioning plans and assesses the cost estimates to advise the Secretary of State for Energy and Climate Change on their suitability for approval.

10.11 The funding arrangements within the FDP are examined by the Nuclear Liabilities Financing Assurance Board (NLFAB)[6] which advises the Secretary of State on the adequacy of the proposed measures; NLFAB will also continue to provide a regular review of funding once the measures are implemented. NLFAB undertakes impartial scrutiny of the FDP in order to provide independent and transparent advice.

10.12 NLFAB membership currently consists of a broad range of experts from relevant fields such as current or former fund managers, pension trustees, lawyers, actuaries and nuclear specialists. This mix of expertise provides for the effective scrutiny of the complex financial arrangements required to manage the nuclear waste and decommissioning costs for new nuclear plants.

10.13 Alongside approval of an operator's FDP, the UK Government also expects the operator to enter into Waste Transfer Contracts (WTCs) regarding the terms on which the UK Government will take title to and liability for the operator's spent fuel and ILW for disposal. WTCs are framed so that operators of new nuclear power stations are charged for waste disposal linked to actual expenditure in all but the most unlikely cases, with a requirement to make provision against projected cost during the operation of the plant.

10.14 The WTCs will include a pricing methodology [Ref 45] which, in particular, will provide for the Waste Transfer Price to be determined at a specified date during the operational lifetime of the power station. In addition, the operator will pay the UK Government a risk premium for fixing the price ahead of the date of disposal to ensure that the taxpayer is appropriately compensated for taking the financial risk of any subsequent cost escalation. Due to the way the price will be determined, the operation of the contracts is projected to be advantageous to taxpayers as the price will include a contribution to the fixed costs of the GDF which would otherwise have been borne by the taxpayer.

[6] NLFAB is an advisory non-departmental public body, sponsored by the Department of Energy and Climate Change.

Financing Disposal of High-activity Sealed Sources (HASS)

10.15 The HASS Regulations [Ref 46] strengthened the financial controls relating to the management and disposal of disused high-activity sealed sources. Financial provision, or an acceptable alternative (for example, return to supplier), must be made to meet the costs of disposal of any HASS to be acquired. Guidance has been issued for UK regulators on the acceptable arrangements that source holders can make to meet the requirements for such financial provision. In England and Wales, the provisions of the HASS Regulations have subsequently been incorporated into EPR10; this did not involve any change in the scope or nature of the regulatory regime.

Chapter 11 Monitoring Progress Towards Implementation of the National Programme

11.1 As has been demonstrated in the earlier Chapters the UK programme is well established and consists of a range of existing strategies, plans and approaches. These have been referenced in this document and they contain the detail on the milestones, planned objectives, key performance indicators, and governance arrangements for their delivery. These details have not therefore been reproduced in full here as this document provides the overarching structure of our programme rather than seeking to replace the existing strategies.

11.2 However a brief summary of key milestones and activity has been provided below.

VLLW and LLW

11.3 Provided that planning consent and environmental permits are granted for up to 20 vaults, LLWR has sufficient capacity for all the LLW that will be produced by the current decommissioning and waste management programme in England and Wales provided that the LLW generators apply the waste management hierarchy and use the diversion routes. Closure of LLWR is envisaged in 2129.

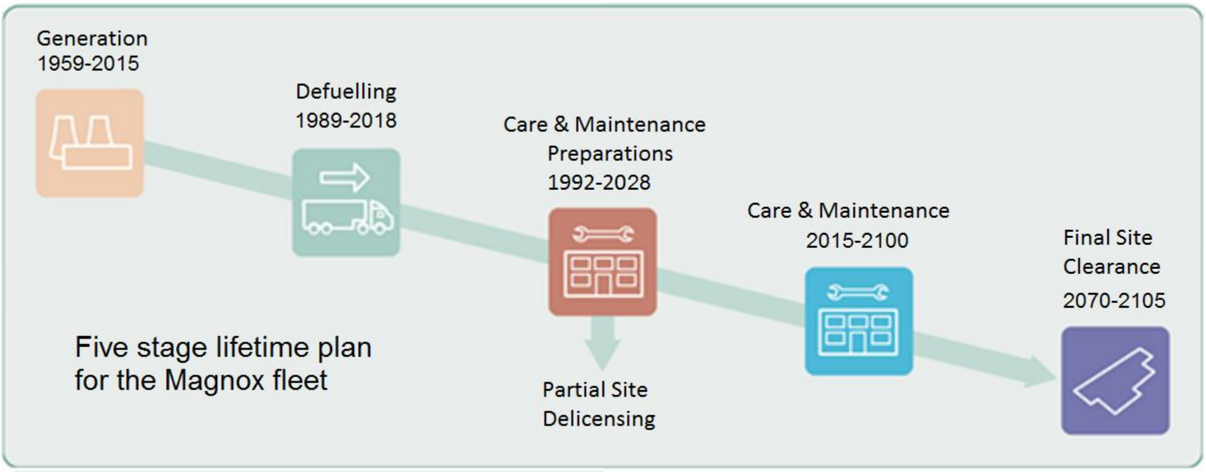
11.4 Operation of the Dounreay LLW repository began during 2015 and is expected to continue until 2028. The facility will have sufficient capacity to dispose of all LLW produced by the decommissioning of the Dounreay and Vulcan nuclear sites.

11.5 LLW Repository Ltd is expected to submit a planning application in Autumn 2015 for the capping of the trenches and existing vaults and the construction of three additional vaults. It is forecast that these additional vaults will provide disposal capacity until 2050.

HAW

11.6 Figure 1-2 provides a high level view of the UK “waste journey” for waste processing, storage and disposal. The following information builds on that concept.

Figure 11-1 Five Stage Lifetime Plan for the Former Magnox Power Plant Sites



11.7 At a much greater level of detail, all sites within the NDA estate have published Lifetime Plans which describe the timescales for their future evolution. The Magnox sites [Ref 47], for example, follow the five stage process shown in Figure 11-1. The Plan for Sellafield [Ref 48] also includes ongoing commercial activities coupled with a much wider and more heterogeneous range of radioactive wastes.

11.8 An operating GDF will be an essential part of the nuclear infrastructure of England and Wales. The current planning assumption for radioactive waste management activities on the various sites is that, a GDF will be available to start receiving ILW and LLW in around 2040 and HLW in 2075. These dates will continue to be reviewed as the GDF site selection and technical assessments progresses [Ref 58].

11.9 Figure 11-2 provides a high level overview of the timescales and main components for the delivery of a GDF in the UK.

Figure 11-2: Time line and main components of the UK Government's Geological Disposal Facility programme

11.10 A draft strategy for the implementation of the Scottish Government Policy for HAW was published during 2015 [Ref 49]. The Strategy sets out the key stages for the effective implementation of the 2011 Policy and outlines key actions that are required from the NDA and the Scottish Government during those phases.

11.11 The initial phase of the Strategy will involve work to review the waste that arises in Scotland and the future management options for that waste. During this phase the NDA and other waste producers and owners will need to review the planning assumptions that are currently in place for the waste in light of the 2011 Policy.

11.12 The second phase of work post 2030 will take forward the waste management solutions identified in the initial phase of work.

11.13 Initial results from Magnox and EDF Energy indicate that there may be a range of waste management and near surface disposal opportunities that could be technically suitable for a good proportion of the HAW streams arising at the Chapelcross, Hunterston A, Hunterston B and Torness sites.

11.14 However, the Scottish Government also acknowledges that for some types of waste (i.e. Raffinate at Dounreay) there are not as yet any suitable for near site, near surface disposal. Further research into alternative final solutions for this waste will therefore be required. This programme of work will include monitoring of the emerging technologies from decommissioning programmes around the world as well as commissioning research and development within the UK.

Spent Nuclear Fuel

Magnox

11.15 The intention is for all Magnox fuel to be reprocessed and, in line with MOP, this is expected to be complete sometime between 2017 and 2020. Recognising that this may not be practicable, the NDA annually reviews the viability and progress of the strategy to inform recommendations on the level of effort to be put into any contingency options.

11.16 As indicated in chapter 7, HLW will be dry-stored in the vitrified product store until a GDF becomes available.

Oxide Fuels

11.17 THORP reprocessing operations are scheduled to end in 2018; the remaining AGR fuel will then be subject to wet interim storage pending geological disposal.

11.18 Sizewell B spent fuel will be progressively transferred to the dry storage facility by 2040 (assuming the current end of generation date of 2035) and is expected to become operational in 2016. This will provide passive storage until fuel is retrieved and packaged, beginning around 2080, and transported over a 20-year period to a GDF.

Exotic Fuels

11.19 The current intention is that all SGHWR and DFR breeder material will be reprocessed and Dragon fuel will be conditioned into disposable packages by 2020. PFR spent fuel will be transferred for storage at Sellafield by 2022.

Skills, Research, Development and Demonstration

11.20 The 2014 NDA People and Skills Strategy [38] contains an analysis of the current and future demands for people and skills in the nuclear decommissioning and waste management fields and sets out an approach for meeting these demands. It describes, for example, the governance arrangements and Focus Areas where specific skills need to be provided and maintained. It also indicates the required budgets for the years 2013/14 and 2014/15. The success of the strategy will be continuously evaluated and the strategy revised as needed.

11.21 Research and development is an ongoing activity by all the major actors in both the state and private sector. The NDA has a part of its web site dedicated to R&D[7] and the whole programme is subject to stakeholder consultation. The NDA publishes a five year R&D plan which currently runs from 2014 to 2019 [Ref 50]. This plan will be updated and published in due course.

[7] http://www.nda.gov.uk/research-and-development/

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