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The Scottish Government

DEPARTMENT OF ENERGY & CLIMATE CHANGE

Strategy for the management of solid low level radioactive waste from the non-nuclear industry in the United Kingdom

Part 1 – Anthropogenic radionuclides

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Contents

1. Executive summary

1.1 This document is the UK strategy for the management of solid LLW arising from the non-nuclear industry, and is primarily aimed at non-nuclear industry waste producers, the environment agencies and waste planning bodies. It will also be relevant to waste disposal facility operators, including the NDA and its site licensed companies. The strategy has been developed by a programme board set up in 2007 by the UK Government working with the devolved administrations following publication of the 2007 Low Level Radioactive Waste (LLW) policy.

1.2 Work on the strategy has been influenced by other developments – in particular the development of the UK Nuclear Industry LLW Strategy and events affecting the oil and gas industries – which are already having a positive impact on the waste disposal market.

1.3 The strategy is intended to:

- provide guidance and background information on this type of waste to enable planning authorities to make informed decisions on planning applications and to respond to concerns from their elected members and constituents.
- clarify the respective roles of waste producers, the environment agencies, planning authorities and the Nuclear Decommissioning Authority to enable decisions to be made that properly recognize the responsibilities of others.
- ensure that waste producers and regulators are fully aware of how the regulatory framework should be applied to LLW, particularly the need for waste management plans, waste minimisation at source and use of the waste hierarchy.

1.4 It does not introduce any new concepts or policy; neither does it introduce any new requirements on permit holders, regulators or other public bodies.

The non-nuclear industry includes a range of different organisations all of which perform vital functions for society. Many of these industries depend on the use of radioactive materials, although some, including the oil and gas industries, produce radioactive waste as a by-product of their processing of material which contains natural radioactivity.

1.5 The UK environmental regulators on radioactive waste arising from the non-nuclear industry hold information on the form of levels and type of radioactivity, and details of permitted facilities to accept such waste. However, the management of radioactive waste from most of the non-nuclear industry, particularly low volume VLLW, is linked with that of commercial and industrial waste, with which it is largely treated. To inform the development of the strategy, further data on waste arisings and disposal practices were therefore sought from the non-nuclear industry across the UK. All the organisations contacted had found appropriate disposal routes for their solid radioactive wastes, almost exclusively to landfill. However, as participation in this study was rather less than anticipated, quantification of waste arisings from the non-nuclear industry across the whole of the UK has been uncertain. Even so, volumes are unlikely to exceed 0.1% of the annual quantities of all waste handled in this country. It is also clear that the disposal network available to the non-nuclear industry for radioactive waste is fragile, and non-existent in some parts of the country. This situation is inevitably leading to excessive transport of wastes from their site of production to ultimate disposal location.

1.6 The difficulties facing the non-nuclear industry are that the volumes of LLW produced are insufficient to drive the provision of exclusive treatment/disposal facilities via the market. In the majority of cases, it will have to rely on disposal networks provided for other wastes. Despite the very low risks associated with their disposal, the fact that the LLW are defined as radioactive can give rise to significant public concern which can be a further deterrent for waste facility operators to provide a disposal service.

1.7 Government does not believe it is appropriate to require operators of commercial waste facilities to take particular wastes. However, via this waste strategy, Government intends to strengthen the robustness of disposal arrangements for the non-nuclear industry. Government wishes to see that existing disposal routes are conserved and that other appropriate routes can be developed or expanded as necessary.

1.8 Government believes that this waste strategy contains information on the non-nuclear industry, which promotes greater understanding of why radioactive wastes are created, what these wastes comprise, how they are managed and the risks associated with their disposal.

1.9 Various organisations have roles to play in helping to conserve and improve the UK-wide disposal network for the non-nuclear industry, and in this waste strategy, Government has set out its expectations of these bodies.

1.10 Waste producers and the environment agencies are encouraged to continue to work together to ensure appropriate application of the waste hierarchy and to consider whether the current network of waste management facilities is being used in an optimum manner. The Environment Agency has produced guidance on waste disposal to landfill in England and Wales, the most appropriate form of disposal in many instances. Furthermore the Government has completed a review of exemption provisions (October 2011) under existing radioactive waste legislation, which will improve the consistency and transparency of the regulation of radioactive waste produced by both the nuclear and non-nuclear sector, particular with respect to Very Low Level Radioactive Waste.

1.11 There is a close inter-relationship between spatial planning and environmental regulation, and Government looks to waste planning authorities to take account of non-nuclear industry radioactive waste disposal requirements, both in their role as consultees to the environment agencies on permit applications, and when they prepare and review local waste plans. This aspect of the strategy is of particular relevance both to new applications from existing disposal facility operators who wish to accept radioactive waste, and to new disposal facilities. However, waste planning authorities should also be aware of the current disposal needs and waste management practices of non-nuclear industries that operate within their areas of responsibility as they prepare their plans.

1.12 The UK nuclear sector LLW strategy reported that demand from the nuclear decommissioning programme may result in additional availability of waste disposal facilities for the non-nuclear sector. In some cases where the NDA develops its own facilities for nuclear waste, there may be opportunities to also accept non-nuclear industry wastes provided that this does not compromise their primary mission in relation to the management of the UK's nuclear legacy wastes. This waste strategy sets out Government expectations on NDA facilities which might potentially be available to the non-nuclear industry.

1.13 The oil and gas sector is a special case within the non-nuclear industry, both because of the physical form of the wastes produced, and their particular radionuclide content. They face imminent difficulties with disposal of certain types of their solid radioactive (NORM) waste. This matter will be the subject of a parallel LLW strategy concerned with Naturally Occurring Radioactive Materials (NORM). This issue will be dealt with in a parallel strategy for NORM wastes in the LLW category.

1.14 Government does not propose to review this strategy for at least five years. However, the liaison groups for the non-nuclear industry that are run by the environment agencies should be the focus for any feedback from regulators and waste producers, on issues emerging from this strategy and on influences felt by them from events that are external to the strategy.

2. Strategy for the Management of Solid Low Level Radioactive Waste from the Non-Nuclear Industry in the United Kingdom – Part 1 (anthropogenic radionuclides)

Introduction

2.1 In March 2007 the UK Government, Scottish Government, Welsh Government and Department of the Environment, Northern Ireland (collectively referred to in this document as 'Government') published the 'Policy for the Long Term management of Solid Low Level Radioactive Waste in the United Kingdom' (The LLW Policy) [Ref.1]. In this policy, the Government recognised that there was a need for a UK-wide strategy for radioactive wastes in the LLW category.

2.2 During the development of the Government's LLW Policy, the non-nuclear industry reported a reduction in the availability of facilities to take their wastes. There was concern about the continued availability of these facilities as well as the need to transport waste over long distances, and the increased costs and environmental consequences associated with this. The LLW policy made a commitment to prepare a UK-wide strategy for the management of solid non-nuclear industry LLW, as part of the Government's commitment to produce a UK-wide strategy. This document fulfils that commitment, and covers the majority of sectors making up the non-nuclear industry and includes general information applicable to the whole of the non-nuclear industry. It expands upon and explains the concepts in the Policy in more detail, and sets out some of its implications for the benefit of a range of stakeholders. However, it does not introduce any new concepts or policy. Indeed, it does not introduce any new requirements on permit holders, regulators or other public bodies.

2.3 Government does not believe it is appropriate, or desirable, to require operators of commercial waste facilities to take particular wastes by way of legislation. However, via this waste strategy, Government intends to reduce the fragility of disposal arrangements for the non-nuclear industry and wishes to see existing treatment routes conserved and other appropriate routes to be established or expanded as necessary to meet the waste disposal requirements for solid LLW arising from the non-nuclear industry.

2.4 In this document the 'non-nuclear industry' means those organisations producing radioactive waste which are not based on nuclear licensed sites. It includes hospitals, the pharmaceutical sector, and research and education establishments, all of which depend on the use of radioactive materials to conduct their business.

2.5 This strategy is complemented by the parallel strategy for LLW arising in the nuclear sector [Ref 2] and a strategy for Naturally-Occurring Radioactive Material (NORM) LLW, which is in preparation (October 2011).

2.6 This strategy for LLW is primarily aimed at:

- non-nuclear industry radioactive waste managers;

- the environmental regulators;
- planning authorities (but especially waste planning authorities); and
- operators of all waste management facilities, including those facilities not hitherto involved in the management of radioactive wastes.

Strategy key point

Government will work with industry, the environmental regulators and planning authorities to strengthen the robustness of disposal arrangements for LLW.

Nature of the waste

General

2.7 The classification of radioactive waste in the UK is set out in Box 1.

Box 1: Categories of radioactive waste

Categories of Radioactive Waste

Solid radioactive waste is divided into three categories according to its radioactivity content and the heat it produces. These categories are:

- **High level waste** (HLW) is waste in which the temperature may rise significantly as a result of its radioactivity, and so this factor has to be taken into account in the design of storage or disposal facilities.
- **Intermediate level waste** (ILW) has lower levels of radioactivity than HLW and does not generate sufficient heat for this to be taken into account in the design of storage or disposal facilities.
- **Low level waste** (LLW) is radioactive waste having a radioactive content not exceeding 4 GBq/te (gigabecquerels per tonne) of alpha or 12 GBq/te of beta/gamma activity. LLW makes up more than 90% of the UK's radioactive waste legacy by volume but contains less than 0.1% of the total radioactivity.

2.8 This strategy is concerned with the third category – LLW. Within the definition of LLW, there is a sub-classification, known as Very Low Level radioactive Waste (VLLW). The definition of VLLW is shown in Box 2.

Box 2: Definitions of Very Low Level Waste

Definition of Very Low Level Waste

Very low level waste (VLLW) is a sub-category of LLW and is defined as either low volume VLLW or high volume VLLW. The principal difference between the two definitions is the need for controls on the total volumes of high volume VLLW being deposited at any one particular landfill or other waste facilities.

Definition of Very Low Level Waste

Low volume VLLW (dustbin loads):
Radioactive waste which can be safely disposed of to an unspecified destination with municipal, commercial or industrial waste ('dustbin disposal'), each $0.1m^3$ of waste containing less than 400 kBq (kilobecquerels) of total activity or single items containing less than 40 kBq of total activity.

For wastes containing carbon-14 or hydrogen-3 (tritium):

- In each $0.1m^3$, the activity limit is 4,000 kBq for carbon-14 and tritium taken together; and
- For any single item, the activity limit is 400 kBq for carbon-14 and tritium taken together.

High volume VLLW (bulk disposals):
Radioactive waste with maximum concentrations of 4 MBq/te (megabecquerels per tonne) of total activity which can be disposed of to specified landfill sites. For waste containing tritium, the concentration limit for tritium is 40 MBq/te. Controls on disposal of this material after removal from the premises where the wastes arose, will be necessary in a manner specified by the environmental regulators.

2.9 The safety of disposals and other waste management practices has been demonstrated by way of several radiological impact assessments. These assessments are described in the annexes to this strategy, with relevant references.

2.10 The non-nuclear industry generates relatively small volumes of radioactive waste from organisations including hospitals, the pharmaceutical sector, and research and education establishments, all of which use radioactive materials which ultimately leads to the generation of radioactive waste. LLW may also be created as a by-product of the processing of material which contains natural radioactivity, principally the oil and gas industry. This is commonly referred to as 'NORM' (Naturally Occurring Radioactive Materials) wastes.

2.11 The majority of solid LLW produced by the non-nuclear industry is similar in its physical and chemical nature to the wide variety of other household, commercial and industrial ("Directive") wastes. It is distinguished from these wastes in that it contains radioactivity that is additional to that which is present naturally and unmodified in the earth's raw materials (and therefore also in all non-radioactive waste). Most LLW produced by the non-nuclear industry contains only very small quantities of this additional radioactivity.

2.12 The volumes of solid Low Level Radioactive Waste (LLW), including a sub-set of this category - Very Low Level Radioactive Waste (VLLW) - produced by the non-nuclear industries are very small compared with the total volume of municipal, construction and industrial wastes. When considered on their own, these wastes are insufficient to drive the provision of dedicated management facilities via the market. Therefore these industries will nearly always have to rely on waste management networks provided for other large volume wastes.

Strategy key point

The characteristics of non-nuclear LLW are broadly similar to those of Directive wastes and hazardous wastes (LLW can also be hazardous waste), with the additional hazard related to radioactivity content. Most LLW, particularly at the lower end of the activity range, can be managed in much the same way as Directive wastes. It is not necessary to make special provisions in waste facilities for the *quantities* of non-nuclear radioactive waste (because these quantities represent only a very small proportion of Directive wastes), but for LLW (other than VLLW) it may be necessary to address the *nature* (radioactive properties) of the waste. These special provisions would be specified in environmental permits issued by the environment agencies.

Low Level Waste (LLW)

2.13 Most disposal of LLW requires a permit under the radioactive waste regulations to be held by both the waste producer and the operator of the waste facility that receives it. LLW can go either to a landfill as a ‘controlled burial’, the national Low Level Waste Repository (LLWR), or may be dealt with by incineration (with or without energy recovery). Currently, arrangements (and permits) for LLW disposals from the non-nuclear sector as ‘controlled burial’ in landfills are not common, and use of the LLWR is usually only for particular types of LLW. LLW disposal, except for that to the LLWR, usually takes place at facilities that are used for other wastes. These facilities are designed to accommodate such wastes, and take into account the waste properties and site selection issues such as proximity to an aquifer.

Strategy key point

Producers of LLW should work with planning authorities, to ensure that such wastes may be effectively handled through the preparation of local plans and in determining planning applications.

Exempt Waste (Very Low Level Waste)

2.14 In the case of VLLW, disposals to landfill or via incineration are made with other Directive wastes, with mixing of VLLW and these other wastes taking place before the material leaves the point of arising. Annex 6 of this strategy sets out the levels of risk associated with low volume VLLW disposal to landfill or via incinerators, and it is because risks to the public and workers are so low that these disposal routes are allowed under exemption provisions (from October 2011). In summary, provided a site produces less than 50 m^3 of VLLW per year, this is classed as low volume VLLW and is exempt[1].

2.15 Under these arrangements, any landfill or incinerator in the UK that is also used for Directive wastes may accept low volume VLLW mixed in with the other wastes. It is existing policy that any such facility which has the appropriate environmental permits from the environment agencies to accept Directive wastes can continue to accept low volume VLLW until it is closed. A new facility may also accept low volume VLLW, again on condition that its operator has the appropriate environmental permits to accept Directive wastes. It must be assumed that any landfill or incinerator receiving Directive wastes could also be receiving low volume VLLW from the non-nuclear industry. To this extent, and bearing in mind that disposing of Directive waste will largely be to facilities that are closest to their point of arising, the Government considers that the present arrangements for low volumes of exempt VLLW are satisfactory.

Strategy key point

Exempt low volume VLLW is currently disposed to landfills and incinerators used for handling Directive waste. No special provisions need to be addressed in environmental permits, and no extra provisions need to be made by waste planning authorities to allow this practice to continue.

The radiological risks and the regulation of low level waste

2.16 There exists a robust regulatory framework, including the application of rigorous standards of radiation protection, to ensure that all LLW is handled in a manner which does not harm human health or the environment. The environment agencies regulate disposals of radioactive waste on or from premises in the UK. In Scotland and Northern Ireland, regulation is under the Radioactive Substances Act 1993 (RSA 93). Since April 2010, regulation in England and Wales has been under the Environmental Permitting Regulations 2010 (EPR 2010). The different legislation used in different parts of the UK does not change the environmental standards for radioactive substances, which are equivalent throughout all of the UK administrations.

2.17 The environment agencies responsible for the regulation of radioactive substances are the Environment Agency in England and Wales (EA); the Scottish Environment Protection Agency (SEPA) in Scotland; and the Department of the Environment's Northern Ireland Environment Agency (NIEA).

2.18 Whilst the environment agencies collect radioactivity data on permitted LLW disposals from individual sites (but not VLLW data) these data do not include volume or mass information. Such data is not necessary for planning purposes, and so the resources required to collect and analyse such data would not be justified.

[1] Higher-volumes of exempt waste usually arise as Naturally Occurring Radioactive Material (NORM); such wastes are a matter for the parallel strategy on NORM wastes. Different considerations apply for exemption of high volume exempt wastes in this category.

2.19 The environment agencies hold information on which waste disposal facilities are currently permitted to dispose of solid LLW.

Strategy key point

The environment agencies hold information on permitted waste disposals (radioactivity data only). They also hold information on the local availability of radioactive waste management facilities.

2.20 The estimated radiation doses to workers involved in handling and disposing of solid LLW and to the public are extremely low, typically less than 1% of the dose received from natural background radiation. However, despite this, the fact that LLW wastes are defined as radioactive can give rise to public concern which can be a deterrent for waste facility operators to provide a disposal service. Annexes to this strategy set out information on what comprises the non-nuclear industry, why it creates radioactive waste, the characteristics of the waste, how wastes are managed and the risks associated with their disposal. This should provide information on the risks associated with radioactive waste management in a clear manner, and put these risks into an appropriate context.

Strategy key point

LLW can be disposed of safely without harm to human health and the environment, and without compromising the rigorous standards of radiological protection set out in legislation.

Strategy key point

Radiological risks associated with disposal of LLW are low when disposal is made to an appropriate facility. Provided that the risks have been calculated and shown to be within the relevant limits, then radiological risk does not prevent the use of any disposal facility referred to in this strategy.

2.21 For a full treatment of the risks associated with LLW disposal, see Annexes 6 and 7.

2.22 When the environmental regulators receive applications for permits under the radioactive waste regulations, the legislation requires that they send copies to relevant local authorities. When they receive applications from waste disposal facility operators to accept radioactive waste (either as high volume VLLW or as LLW), they also consult relevant local authorities. When they liaise with, or consult, local authorities on matters relating to radioactive waste disposal applications, they should ensure direct contact with the most appropriate bodies within local authorities, i.e. the waste planning authorities.

2.23 The environmental regulators co-ordinate meetings of the non-nuclear industry. In England and Wales, the Small Users' Liaison Group is run by the EA which includes representation from the Northern Ireland Environment Agency, and in Scotland, SEPA runs the Scottish Non-Nuclear Industries' Liaison Group. These are fora for effective liaison, communication and consultation between non-nuclear users of radioactive substances and the regulators. Concerns expressed at these fora have formed part of the impetus to develop this strategy. Government expects these meetings will continue to provide the opportunity for the non-nuclear industry to provide feedback to the regulators, and hence to Government, of any impacts of the strategy on their operations.

Strategy key point

Non-nuclear industry liaison group meetings will be invited to comment on the impacts of this strategy, and make recommendations for improvement or update.

2.24 A substantial proportion of radioactive waste arising from the non-nuclear industry falls into the category of low volume VLLW. Low volume VLLW may be disposed of with Directive wastes at facilities that do not themselves require permits under radioactive substances legislation. In issuing environmental (waste) permits to such facilities, the environmental regulators should ensure this co-disposal of Directive and radioactive wastes falling within the definition of low volume VLLW is not inadvertently excluded because of the way in which waste is described in the permits.

2.25 Government recognises that the radioactive properties of LLW represent only one of several possible hazards. For instance, much LLW arising in the medical sector is also classified as clinical waste, which constrains the choice of available disposal routes. However, these other hazardous properties do not affect the overall direction of the strategy, and no changes are proposed in this regard. When a waste producer is considering the available options for disposal, obviously all hazardous properties of the waste need to be taken into account.

2.26 The management of radioactive waste can lead to radiation doses for both workers and members of the public. A balance needs to be struck, particularly in the case of decay storage where a slight decrease in public dose can result in a slight increase in worker dose. This balance is a matter for the regulators, both the environment agencies and the Health and Safety Executive (HSE). A memorandum of understanding between these regulators is in place, and a mechanism exists by which the regulators can determine the appropriate balance on a case by case basis.

The role of individual organisations

2.27 A number of organisations have roles to play in helping to conserve and improve a UK-wide disposal network for the non-nuclear industry solid LLW, and in the paragraphs below, Government summarises its expectations of these bodies as follows:

- waste producers should ensure appropriate application of the waste management hierarchy and optimum use of the network of facilities that is available for disposal of their waste. This aspect of the strategy is of particular relevance to the use of existing disposal facilities, and the regulators will be expected to play an important role in its implementation; and
- waste planning authorities should take account of non-nuclear industry radioactive waste disposal capacities and requirements, both in their role as consultees to the environmental regulators during permit determinations, and when they prepare and review local waste plans. This aspect of the strategy is of particular relevance to new applications from disposal facility operators for both existing facilities who wish to take radioactive waste in the future, and to new disposal facilities.

The role of waste producers

2.28 The 2007 LLW policy [Ref.1] stated that plans for the management of all radioactive waste must be developed by waste managers. These plans are a matter of public record, and can be accessed via the public registers of the environment agencies. Regarding the non-nuclear industry, the 2007 LLW policy stated that waste management plans should be proportionate to the scale of waste production and holdings, as agreed with the regulator, and that regulators would clarify their requirements of the non-nuclear industry in light of the general principles in the policy statement. Effectively, it is a matter for the waste producers, in discussion with the regulators, to consider what emphasis should be placed on each of the key policy requirements by individual waste producers. The Environment Agency has issued guidance and briefing notes on the 2007 LLW policy definitions of LLW and VLLW, and on the regulatory requirements for disposal of these wastes in England and Wales [Ref.3]. This guidance is welcomed by Government, and will go some way to addressing certain issues that have arisen during the data collection programmes carried out to support this strategy.

Strategy key point

The environment agencies will continue to develop and update guidance for waste producers on the management of LLW.

The Proximity principle[2]

2.29 It is recognised that waste planning by waste producers involves balancing regulatory and policy requirements with what appropriate disposal routes are actually available. In the case of most low volume VLLW from the non-nuclear industry, its fate is purely dependent on that of Directive waste with which it is mixed at the point of production i.e. waste producers have no influence on choice of disposal facility (other than whether

[2] The Proximity Principle' is referred to in some situations in the UK as 'the Principle of Proximity'. The former phrase has been used in this Strategy because it is the formulation used in the National UK LLW Policy. The two terms have the same meaning and there are no different requirements inferred by either term.

incineration or landfill routes are used). However, in the case of deciding on disposal routes for LLW, Government wishes to see appropriate and explicit consideration of the proximity principle when deciding upon an appropriate disposal route. This principle should not dominate the waste plan developed by producers, but should be given appropriate consideration by both the environmental regulators and non-nuclear industry waste producers.

2.30 Government does not intend, in this strategy, to define 'proximity' by reference to any particular geographical area. 'Appropriate and explicit consideration' means that proximity must be a feature of any options' assessment process which supports a proposed waste management plan. The 'appropriate explicit consideration' means that the proximity principle will assume a different importance in an options' assessment for, say, a site producing large volumes of contaminated steel, for which only a limited number of decontamination facilities are available, to a hospital generating low volumes of radioactive waste suitable for (local) incineration or landfill.

Strategy key points

The proximity principle needs to be a consideration, alongside other considerations, in any waste management plan prepared by LLW producers. The principle is a component of work and decisions by waste producers, the environment agencies, and planning authorities.

Waste management organisations

2.31 A number of waste management facilities are available for the management of LLW and VLLW. There is no central register of such facilities due to the changing nature of the market – new facilities are being made available and old (or full) landfills may cease trading. The environment agencies can supply advice on facilities known to them in any particular geographical area (but cannot endorse any particular facility or company). Other sources of information are the websites of waste management companies, and information made publicly available by waste planning authorities as part of the planning process.

The role of planning authorities

2.32 Existing national planning policy provides the framework for providing the waste management infrastructure for dealing with the wastes produced in this country. In England, this policy is set out in Planning Policy Statement 10 (PPS10) [Ref. 4] *Planning for sustainable waste management*, whilst in Wales the relevant planning policy statement is TAN21 and in Scotland NPPG 10 'Planning and Waste Management'.

2.33 By implementing national policy in PPS10 and its equivalents throughout the UK, waste planning authorities should plan for all relevant waste streams, including LLW, and to ensure that sufficient waste management facilities are in place. In doing so, they are expected to provide a framework in which communities take more responsibility for their own waste, whilst pushing waste up the hierarchy and ensuring waste is handled safely. This means that LLW sent to waste disposal facilities should normally be disposed of at one of the nearest appropriate installations.

Strategy key point

Communities which benefit from the beneficial uses of radioactive materials (including direct benefit such as the use of radiopharmaceuticals, and indirect benefits such as contributions to a local economy from commercial bodies using radioactive materials) should take a share in the responsibility for managing the radioactive wastes which inevitably arise from their use, where possible, while recognising that each and every local authority can not necessarily be self-sufficient in the matter of waste management.

2.34 Data has shown that the majority of non-nuclear industry wastes are of very small volume in comparison to the annual volumes of municipal waste (very unlikely to exceed 0.1% by volume, and there is some evidence that it will reduce (see Annex 3). Therefore, waste planning authorities are unlikely to need to make any special provisions to cope with an increase in volumes of radioactive waste.

2.35 The legal responsibility of the environment agencies, through the environmental permitting system, is to decide in detail which waste types can be taken to a particular site. In the case of facilities requiring environmental permits under radioactive waste regulations (i.e. those wishing to take high volume VLLW and LLW), planning authorities should be consulted on these applications by the environment agencies, who themselves will comment on the adequacy of risk assessments supporting the applications. The planning and pollution control systems are separate but complementary. Planning authorities are not expected to deal with issues that fall within the remit of the pollution control authorities, and should work on the assumption that the relevant pollution control regime will be properly applied and enforced. A waste facility that is likely to deal with LLW cannot be built or operated without first obtaining both planning permission and an environmental permit (and any other relevant consents).

2.36 It must therefore be assumed that a permitted operator of any landfill or incinerator receiving Directive waste could also apply to the environment agencies to take LLW under radioactive waste regulations. Unlike the network of facilities available to take low volume VLLW there are considerably fewer facilities across the UK that currently take LLW. Nonetheless, operators of existing and new facilities may wish to apply to take LLW at any time.

2.37 Public consultation is a feature of planning applications, but in the case of applications for dealing with radioactive wastes, planning authorities are encouraged to use the material in this strategy as further background information for public consumption during the consultation process. Public understanding and knowledge of the need for, and risks from, radioactive waste disposal appears to be at a lower level than understanding and knowledge of conventional waste management.

2.38 To assist planning authorities, Government expects that as a minimum, it should be feasible for the environmental regulators to be able to provide to waste producers (or other interested parties), up-to-date, timely and centrally available, lists of all waste disposal facilities permitted under the radioactive waste regulations to accept and dispose of radioactive waste.

2.39 Government recognises that collaborative efforts by several authorities are not only desirable but necessary. There are many local authority areas which, for instance, have a low density of medical establishments generating radioactive waste and it would not be reasonable to draw boundaries within which all wastes should be managed. But conversely, there are areas of the UK, containing several local authorities, where management of wastes within these areas would be a viable commercial proposition for any company wishing to establish facilities for such management.

Strategy key point

Waste planning authorities should consider how to manage LLW and VLLW arising in their areas as part of the preparation of their local waste plans. They should seek advice from waste producers and the environment agencies to ensure that the waste is being sent to a suitable waste management facility. If necessary and feasible, they should work with other waste planning authorities to share facilities.

The environment agencies will supply information on disposal facility locations, on request, to waste producers and planning authorities to assist their decisions.

The role of the NDA

2.40 The Nuclear Decommissioning Authority (NDA) is responsible for the decommissioning of public-sector civil nuclear sites in the UK. It has produced waste strategies for all its anticipated waste streams, and completed consultation on the UK Strategy for the Management of Solid Low Level Radioactive Waste from the Nuclear Industry (hereafter referred to as the UK Nuclear Industry LLW Strategy) in November 2009. The strategy was published in August 2010 [Ref. 2].

2.41 Decommissioning the UK's public-sector civil nuclear sites will create large amounts of LLW and VLLW, likely to be well in excess of the current capacity at existing disposal facilities on nuclear sites. The UK Nuclear Industry LLW Strategy identifies how it will ensure availability of management and disposal routes for VLLW and LLW by applying the waste management hierarchy, developing new routes for the management and disposal of LLW and optimising the use of existing facilities. This includes seeking flexible, risk based, disposal routes for lower activity wastes based on robust information and transparent decision making processes. The strategy sets out how application of the waste management hierarchy presents significant opportunities for effective management of LLW, including due consideration for safety, environmental responsibility, and cost-effectiveness. Additional alternative waste treatment and disposal routes are being pursued.

2.42 The UK Nuclear Industry LLW Strategy recognises the importance of continued availability of the use of the LLWR to ensure that only those wastes requiring engineered multi-barrier containment and disposal are consigned to that site.

2.43 In summary, the UK Nuclear Industry LLW Strategy sets out how the nuclear industry, with supply chain support, can ensure continued capability and capacity through applying flexibility in the determination of treatment and disposal routes and giving proper consideration to all viable options. These options include in-situ disposal; development of new facilities on or adjacent to sites for management of waste from those sites; or extended facilities to manage wastes from a number of sites; or the development of new facilities away from nuclear sites.

2.44 The demand from the nuclear sector for waste disposal facilities is expected to stimulate new opportunities for waste management operators. Operators are already taking up this opportunity. The potential widening of the commercial treatment and disposal network is expected to also benefit the non-nuclear industry. As most of the non-nuclear industry only produces very small quantities of LLW and VLLW, it is not anticipated that it will. alone, stimulate investment in new facilities However, this non-nuclear waste strategy is complementary to the UK Nuclear Industry LLW strategy and will seek to utilise any treatment and disposal routes developed to ensure capacity for the management of LLW arising in the UK.

2.45 Where the NDA have facilities that support the NNI strategy, it is recognised that these routes will only be made available where it is appropriate and practicable and doesn’t impact on the delivery of the NDA mission and will be under appropriate commercial and regulatory terms.

Strategy key point

The NDA can and will make provision within its supply chain arrangements for the disposal of non-nuclear LLW, provided that such provision does not compromise (e.g increase the costs of) its primary mission which is the management of the UK’s nuclear waste legacy.

2.46 LLW Repository Ltd will continue to play a central role in supporting waste producers to work collaboratively to take advantage of its comprehensive integrated waste service for the treatment and disposal of LLW from the nuclear and non-nuclear industry.

2.47 Should further treatment or disposal capacity be developed by the supply chain, it will be the responsibility of NNI waste producers to engage with the supply chain to take advantage of these treatment or disposal routes as appropriate, again based on suitable commercial and regulatory terms.

2.48 In line with Government expectations, and only where necessary, NDA will continue to make facilities available for treatment and storage of redundant radioactive sources preparatory to the construction and operation of permanent disposal facilities.

LLW minimisation and the waste management hierarchy

2.49 Application of the waste hierarchy is already embodied in the LLW Policy and is implemented by the environmental regulators through use of ‘Best Practicable Means’

(BPM) and 'Best Available Techniques' (BAT) assessments. For example, environmental permits contain conditions such as;

'The [permit] holder shall use best practicable means to ensure that no unnecessary radioactive waste is generated', and

'The [permit] holder shall use best practicable means to minimise the volume of, and the total radioactivity in, all of the radioactive waste that will require disposal'.

2.50 The waste hierarchy requires that the following steps be undertaken by waste producers:

- Waste prevention: this is a fundamental principle for the management of LLW.
- Waste minimisation: there are resource and cost benefits in minimising the amount of LLW to be managed.
- Waste reuse: this defers waste production and extends the life of resources
- Waste recycling: this is the preferred way forward for the treatment of some LLW, mainly metals.
- Volume reduction: this ensures best use of disposal capacity
- Waste disposal: waste disposal capacity is a precious resource and it must be used sparingly and as a last resort. Waste disposal by way of incineration with energy recovery is preferable to any other waste disposal mechanism, where this management technique is practicable.

2.51 In principle, there is no reason why the waste hierarchy can not be applied to radioactive wastes, although special considerations apply. For instance, the 'avoidance' step in the hierarchy will have already been applied to non-nuclear users of radioactive material, in part, by way of the Justification Regulations [Ref. 5]. A person may not use radioactive materials for any practice unless the practice has been 'justified', and this justification includes a consideration of the wastes produced in addition to the initial use of the radioactive material. However, it is recognised that there are limited opportunities to apply the hierarchy to low level radioactive waste generated historically within the non-nuclear industry; therefore a large component of this strategy is focussed on disposal. Furthermore, the primary objective of radioactive waste management is the protection of human health, and this objective over-rides any consideration of the hierarchy.

2.52 Application of the waste management hierarchy needs, therefore, to be done on a case-by-case basis, and there is no intention in the strategy to unreasonably constrain management practices, provided that good practice (in legislative terms, 'Best Practicable Means' or 'Best Available Techniques') are applied to waste minimisation.

Strategy key point

The principles of the waste hierarchy, and the waste reduction step in particular, apply equally to radioactive wastes as they do to Directive wastes. However, the practical application of these principles may be different; the protection of human health over-rides any consideration of the hierarchy.

2.53 Hence, the requirements imposed by the regulators are for the producers of radioactive waste are in place to ensure:

- that radioactive waste is not generated unnecessarily;
- minimisation of radioactivity in all disposals; and
- minimisation of the effects of disposals on environment and members of the public.

2.54 LLW minimisation can be divided into three approaches:

- Separating out wastes where they are mixed or before they can become mixed.
- Reducing the activity levels of waste through decontamination.
- Characterise waste such that it can be exempted, if below certain concentration thresholds.

2.55 It falls to the waste producers to demonstrate BPM/BAT to the regulators, including a consideration of the economic component of BAT to identify the most cost-effective solutions. However, it is incumbent on the regulators to help waste producers fully understand their permit conditions, to publish guidance on such matters as BPM and BAT, and make best use of existing disposal options. The Environment Agency has issued guidance on BAT to support EPR [Ref. 6] and SEPA guidance on BPM is included on the SEPA website; both documents help satisfy this regulatory responsibility.

Waste characterisation

2.56 In order to obtain good quality information, waste producers need to undertake effective characterisation programmes to determine what waste will arise and when. Characterisation at all stages of the waste management cycle is important; it can yield most benefit before materials become waste, which supports good decision-making so as not to foreclose options.

Decay storage

2.57 Decay storage is an acceptable method by which some radioactive wastes, in some circumstances, are best managed, at least as an interim step to final disposal. Decay storage is not acceptable if the sole purpose of the storage is to defer waste management costs to the future.

2.58 Neither the 2007 policy nor the strategy preclude, explicitly or implicitly, decay storage to VLLW levels. The question of how much permitted waste may be accumulated is a matter for discussion and agreement with the environmental regulators.

2.59 It is incumbent on a waste generator to make an initial assessment on whether decay storage is appropriate. A number of factors need to be taken into account, including operator dose, the security of storage facilities, the length of time required in order to meet the desired reduction in activity etc. For permitted facilities, a case for decay storage needs to be made to, and accepted by, the environmental regulators as part of a waste management plan. For situations where the waste is exempt, no regulatory submission is required.

Strategy key point

Waste management plans prepared by waste producers should consider the decay storage option if appropriate to the waste type and particular circumstances.

Supplementary information

2.60 In order to address the challenges associated with managing radioactive wastes from the non nuclear industries, Government has included explanatory information on the non-nuclear industry, so as to promote greater understanding of:

- why these wastes are created;
- what these wastes comprise;
- how these wastes are managed; and
- the risks associated with the disposal of these wastes.

2.61 This information is provided in annexes to this strategy as set out below.

- Background, definitions and scope (Annex 1);
- Societal dependence on the non-nuclear industry (Annex 2);
- Waste arisings from the non-nuclear industry (Annex 3);
- Radioactivity and radiation dose(Annex 4);
- The regulatory framework (Annex 5);
- Assessment of risk from disposals of non-nuclear industry LLW and VLLW (Annex 6);
- Risks from radiation (Annex 7);
- Details of the Appraisal of Sustainability (Annex 8).

Annex 1: Background to the Strategy

Introduction

A1.1 In March 2007 the UK Government and devolved administrations for Scotland, Wales and Northern Ireland published a policy for the long term management of solid low level radioactive waste in the UK, hereafter referred to as the '2007 LLW policy' [Ref. 1]. The 2007 LLW policy requires a strategy to be developed for the management of solid LLW from the non-nuclear industry. The main document fulfils this requirement.

A1.2 The strategy has been developed within the framework of principles set out in the policy, these being:

- use of a risk-informed[3] approach to ensure safety and protection of the environment;
- minimisation of waste arisings (activity, volume and mass) by way of the 'waste hierarchy';
- forecasting of future waste arisings, based upon fit for purpose characterisation of wastes and materials that may become waste;
- consideration of all practicable options for the management of LLW;
- a presumption towards early solutions to waste management;
- appropriate consideration of the proximity principle and waste transport issues; and
- in the case of long term storage or disposal facilities, consideration of the potential effects of future climate changes.

Scope of the strategy

The non-nuclear industry

A1.3 For the purposes of this strategy, the non-nuclear industry is defined as '*those organisations which produce radioactive waste and are not part of the nuclear industry*'[4]. 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 etc. Other organisations process material which 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 which may be subject to regulation.

Waste types

A1.4 The strategy deals only with Low Level Radioactive Waste (LLW), and its sub-set, Very Low Level Radioactive Waste (VLLW) in solid form. Other strategies deal with the direct disposal of liquid and gaseous wastes to the environment [Ref. 7].

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[3] The strategy does not adopt a strict 'risk based' approach. Risks calculated and presented in mathematical terms are an important contributor to the strategy, but political and social factors also need to be taken into account.

[4] The nuclear industry includes those sites which hold a nuclear site licence under the Nuclear Installations Act 1965.

A1.5 This strategy also refers to other types of waste that are disposed of via similar routes to non-nuclear industry radioactive waste; for example municipal or household, commercial, industrial, controlled, clinical and hazardous wastes. The definitions are:

- Directive waste (defined in the Environmental Protection Act 1990) is 'waste arising from household, industrial and commercial premises and ultimate disposal is via landfill and incineration'.

- Clinical and hazardous wastes are special types of Directive wastes that must be disposed of to certain types of facility.

A1.6 Consideration of these definitions, and the more general point that the other hazardous properties of the waste (in addition to radiological hazards), must be taken into account in waste management approaches. LLW and VLLW are closely akin to other Directive Wastes, and are managed in a similar fashion to these other wastes. For instance, much LLW and VLLW arising in the medical sector is also Clinical Waste, for which disposal by incineration is often the most appropriate approach.

Appraisal of sustainability

A1.7 The UK Government determined, after taking advice from the relevant experts, that this non-nuclear industry waste strategy did not fall under the requirements of the Strategic Environmental Assessment (SEA) Directive [Ref. 8]. Nonetheless, the related process of Sustainability Appraisal (SA) was applied to the strategy on the basis that it should ensure that environmental, economic and social perspectives would be covered in a systematic fashion. Cross-references between this appraisal and this strategy are shown in Annex 8.

Transport safety

A1.8 The safety of radioactive materials and waste when in the course of a journey is of paramount importance, but is not covered in this strategy. These matters are dealt with by the Department for Transport, and certain regulations apply to such transport [Ref. 9].

Development and future of the strategy

A1.9 This strategy has been developed to support the 2007 LLW Policy, and follows a public consultation [Ref. 10, 10a]. This policy recommended that this strategy be developed by following three steps:

- firstly, the estimation of the extent and geographical distribution of LLW arisings from this sector. This was undertaken by Government working in conjunction with the NDA and the environmental regulators;

- secondly, a process to develop a UK-wide strategy and identification of future arrangements for its delivery, again undertaken by Government working in conjunction with the NDA. The strategy was to emphasise the importance of the waste management hierarchy, particularly waste avoidance. The involvement of the NDA was to ensure that there is appropriate integration of the nuclear and non-nuclear industry strategies. There needed to be appropriate public and stakeholder engagement as the strategy was developed; and

- thirdly, ensuring the provision of sufficient opportunities within national and local planning strategies, as appropriate, to meet the non-nuclear industry disposal needs as set out in the UK-wide strategy (implementation).

A1.10 The development of this strategy has involved data collection and data assessment programmes [Ref. 11, 12], and engagement with a number of key stakeholders including non-nuclear industry LLW producers, representatives from Government (including the Devolved Administrations), regulators, and planning authorities (see Annex 3).

A1.11 A draft strategy was subject to formal consultation during 2010 – 2011 [Ref. 9, 9a].

A1.12 Work will continue to be undertaken to support the development of the parallel NORM strategy.

A1.13 Government will use information gathered by the waste planning authorities and environmental regulators as the basis to inform a review of this strategy in years to come. Based on the studies undertaken to inform this strategy, it would appear that for the majority of non-nuclear industry LLW adequate treatment and disposal capacity is currently available. However, this capacity will be subject to Government review, to determine whether further strategic measures are required.

A1.14 Membership of the Government's programme board which oversaw the development of this strategy appears as Annex 9.

Annex 2: Societal dependence on the non-nuclear industry

General

A2.1 The use of radioactive materials in a variety of circumstances is essential to the UK economy and to improving the nation's health. Government recognises these useful benefits, but demands that these uses can only be carried out provided that the strict standards of radiological protection can be complied with. These standards apply equally to the radioactive waste which is inevitable generated as a result of the use of radioactive materials.

A2.2 The following section sets out why the different sectors that comprise the non-nuclear industry produce solid radioactive waste. Many organisations use radioactively-labelled chemicals called tracers, to follow chemical and biological reactions in the human body. The ease of detection of the radiations emanating from these radioactively labelled tracers is what makes them so useful. The nature of the chemical to be labelled is dependent on its application, for example, the term 'radiopharmaceutical' applies to tracers used in the diagnosis or treatment of a disease. Radiopharmaceuticals and other radioactive tracers are purchased from specialist commercial organisations that produce the required radioactive isotopes either from a nuclear reactor using the processes of fission or activation, or by the bombardment of a target material with a beam of charged particles in a machine called a cyclotron. The radioactive isotopes are then attached to a pharmaceutical to create the radioactive tracer which targets specific organs or diseased tissue. Examples of radioisotopes commonly used by the non-nuclear industry are given in tables and boxes in this Annex.

Hospitals

A2.3 Radiopharmaceuticals are essential for the diagnosis and treatment of disease (mostly cancers) and hence are widely used in nuclear medicine departments in the National Health Service (NHS) and private hospitals. In 2003/4, there were 252 nuclear medicine centres in the UK, at which around 670,000 individual procedures were undertaken per year [Ref. 13]. Between them, these centres employed 160 clinical scientists, 660 technicians, including radiographers, and 120 dedicated pharmacy personnel [Ref.14].

A2.4 In the 10 years before these data were collected, there was an increase of nearly 40% in the annual total number of nuclear medicine procedures performed, and such procedures are likely to increase as new methods are found involving the use of radionuclides for diagnosing and treating medical conditions [Ref. 14].

A2.5 The vast bulk of procedures are for diagnosis of medical conditions (98%). Most diagnostic procedures (93%) involve imaging, in which the patient is administered a radiopharmaceutical which concentrates in the area of the body under investigation. Radioisotopes used in imaging procedures are of short radioactive half life and emit gamma rays which can be detected by instruments (scanners) that are outside of the body.

A2.6 The remaining diagnostic procedures are called non-imaging, in which the radiopharmaceutical is administered to the patient, again, so it targets the organ of interest, but measurements of the radioactivity are made on material that is eliminated from the body (in particular in excreta or gas from the lungs). Most radioisotopes used in non-imaging procedures are also of short half life – not all rely on gamma rays, and some detection is by way of beta particle emission.

A2.7 In a very small number of procedures (2% of nuclear medicine procedures), higher quantities of radioactivity within administered radiopharmaceuticals are used to kill cancer cells. The most established application is the use of iodine-131 for treatment of diseases of the thyroid, though the range of therapies, and radionuclides used, is now expanding. Although much less common than diagnostic procedures, the higher levels of radioactivity used in these therapeutic procedures, coupled with the longer half life of the radionuclides used, and the prolonged inpatient stay, result in the generation of solid waste which is of higher radioactivity and volume.

Box .2.1 The use of Technetium-99 (TC-99m) in nuclear medicine

The use of Technetium- 99 (Tc-99m) in nuclear medicine

Tc-99m has a short half life (6 hours), it is readily eliminated from the body, and as it decays with the emission of a gamma ray, its presence within the body can be detected by scanners placed around the patient. It is the most widely used radioisotope in nuclear medicine – accounting for nearly 80% of procedures. It decays into Tc-99 which is a radioisotope that decays via weak beta particle emission, and is of very long half life.

The commonest use of Tc-99m is in the investigation of bone conditions (e.g. detection of cancer) and heart and lung diseases. Different biochemicals labelled with Tc-99m are given to the patient – these target the organs under investigation. Irregularities can be deduced from the picture of Tc-99m distribution that is picked up by the scanners.

Although Tc-99m is very commonly used in nuclear medicine, the practice of "decay storage" means that in most cases, either very little radioactive waste, or only non-radioactive waste, is created.

A2.8 Some hospitals also use radiopharmaceuticals to follow (or trace) reactions in materials sampled from the body (known as 'in vitro' analysis). In this application, the levels of radioactivity are much lower than in those used directly in people, but the radioisotopes used tend to have a longer half-life, e.g. tritium (H-3), carbon-14, phosphorus-32.

A2.9 The bulk of radioactivity administered to patients for either diagnostic or therapeutic purposes is eliminated by them via excreta to the sewers. The environment agencies regulate these discharges from hospitals. Risks to sewage workers and the public from discharges at current levels are calculated to be very low, mainly because the radioisotopes involved are usually of short half life and the radioactivity decays quickly [Ref.14].

A2.10 Solid radioactive wastes arise as a result of traces of radiopharmaceuticals in used syringes, needles, vials from which radiopharmaceuticals have been withdrawn and absorbent or protective materials (e.g. swabs, dressings, sheets and plastic film) which may be contaminated with small amounts of radiopharmaceutical. Many hospitals are encouraged to store solid radioactive waste prior to disposal. This is called 'decay storage', and its purpose is to allow short lived radioisotopes in the waste to decay to very low levels, a practice which minimises the radiological impact of the finally disposed waste. However, this requires the provision of storage space and availability of resources to manage the accumulated waste. For the most commonly used radionuclides, particularly technitium-99m, the majority of hospitals can provide such storage resources.

A2.11 Traditionally, most hospital waste has been designated as clinical waste, much of which is incinerated. However, hospitals are now being encouraged to categorise and segregate wastes at source, which may result in some radioactive wastes being discharged into a non-clinical waste route.

Pharmaceutical Industry

A2.12 The pharmaceutical industry carries out drug and technology development in specific areas of disease research, and in doing so, makes wide use of radiopharmaceuticals. In 2005, the UK pharmaceutical industry directly employed 68,000, just under 40% of whom were directly involved in research, and between 10 and 20% used radioactivity. Solid VLLW from the pharmaceutical industry comprises general laboratory plastics, vials, sharps (i.e. needles and blades), gloves and any material which may be contaminated.

Box 2.2 The use of radiopharmaceuticals during disease research

The use of radiopharmaceuticals during disease research

- **Target identification** - studying how diseased tissue differs from normal tissue.
- **Screening** - once the disease target (a type of protein) is known, compounds that interact with the target are labelled with radioactivity and used to identify other compounds (which may be potential treatments for the disease)
- **Selectivity** - the compounds are then tested at other targets where activity might result in side effects
- **Bio imaging** - when a potential drug has been identified, it has to be shown to be selective for diseased tissue. This is a legal requirement before the start of clinical trials.

Biotechnology industry

A2.13 Biotechnology is the exploitation of biological processes for industrial and other purposes, especially the genetic manipulation of micro-organisms for the production of antibiotics and hormones. Biotechnology companies use small amounts of radioactivity in a range of diagnostic and life science research including:

- Genomics, stem cell biology, and bio-nanotechnology, which provide a basis for new technologies in healthcare, food safety, plant and livestock breeding, and bioprocessing;

- Whole organism biology relevant to the understanding of diet and health, ageing, animal health and welfare, infectious diseases and immunity and crop productivity;
- Biological populations and systems that underpin agricultural sustainability, biodiversity and novel bio-based and renewable processes for energy and manufacturing.
- Radioactivity is also used in therapeutic products designed to treat diseases such as prostate cancer and relieve pain in bone metastases.

A2.14 VLLW from biotechnology companies includes equipment to count the radioactivity, gloves, protective overalls and vials, and the waste is treated as either clinical or directive waste.

Universities, colleges and other research laboratories

A2.15 Radioactive tracers are used in universities, colleges and other research laboratories, to study the incorporation of chemical compounds into cells and organisms and also to study their transfer and metabolism. Box 2.3 contains two examples of the use of radioisotopes in disease research.

Box 2.3. Examples of disease research using radioisotopes

Examples of disease research using radioisotopes

Some rare childhood diseases are caused by inherited errors in metabolism. Blockages in various metabolic pathways are investigated using the radioactive labelling of fatty acids (with tritium) and amino acids (with carbon-14) in cell samples taken from the patients, that are then grown in culture. These investigations are a national service and help around 300 patients a year.

Part of a study into the causes of cystic fibrosis involves the use of the radioisotope calcium-45 in cultured cells from the bronchial tubes, to measure calcium movement across cell membranes.

In both examples, the use of radioisotopes currently provides the greatest sensitivity compared to techniques not involving radioactivity. This is because of the ease of detection of the radioactive labelling.

A2.16 Some research into plants, microbes and food also involves the use of radioactive tracers, and this work has enabled developments that are of great benefit to people around the world (see Box 2.4 for examples).

Box 2.4 Examples of developments made possible through use of radioactive tracers in research

Examples of developments made possible through use of radioactive tracers in research
• Food crops with increased resistance to drought and increased resistance to disease, thereby reducing the need for chemical treatments • Food crops that can trap their own nitrogen, thereby reducing the need for chemical fertilizers • Food crops with improved yields and nutritional value • Characterisation of toxins resulting from food spoilage • Production of drugs and antibiotics from microbial and plant sources • Gene mapping of plants and microbes

A2.17 The last survey of use of radioactivity by these sectors was in 2002, and at that time it was estimated that there were around 10,000 monitored workers. Since then, there has been a decline in numbers working with radioactivity as people actively seek non-radioactive methods. However, in some instances, in particular in the field of genome research, techniques using non-radioactive alternatives do not offer sufficient sensitivity, and work with radioactive tracers continues to dominate research methods.

A2.18 Radioactive waste arising at medical schools and biomedical research laboratories is similar to that from hospital laboratories and the pharmaceutical and biotechnology industries. The waste typically includes disposable plasticware, sample tubes, paper and plastic coverings, paper tissues, organic liquids that are used to count certain types of radioactivity (called scintillation fluids). Agricultural and animal research will result in rather more bulky wastes (for example plant matter and animal bedding). Most radioisotopes used by these sectors are of short half life, for example, sulphur-35, phosphorous-32, phosphorous-33, iodine-125 and calcium-45. As in the case of hospitals that use radioactivity, most research institutions will store used radioactive materials from 6 months up to 3 years, to allow short lived radioisotopes to decay, so as to minimise the radioactivity in the eventual wastes sent for disposal. For some studies, it is essential to use the longer lived radioisotopes of tritium (H-3) and carbon-14.

Veterinary medicine

A2.19 In 2000, there were about 10,000 veterinary surgeons in the UK. Some of these use radioisotopes to diagnose and treat disease in animals but very infrequently, compared to in regular medicine. Treatments are mostly at universities and specialist animal referral centres, rather than in general practice. The radioisotopes most commonly used are technitium-99m and iodine-131. Technitium-99m is used in the diagnosis of disease, almost exclusively in horses. However, the quantities used and its short half life (6 hours) mean that radioactivity in waste is reduced to a negligible level by 24 hour storage. Iodine-131 (half life 8 days) is used therapeutically in cats. Treated animals are usually kept within veterinary practices for about a month, so that their excreta can be collected and stored to allow for decay of the iodine-131. Hence very little solid radioactive waste is generated by the use of radioisotopes in veterinary medicine.

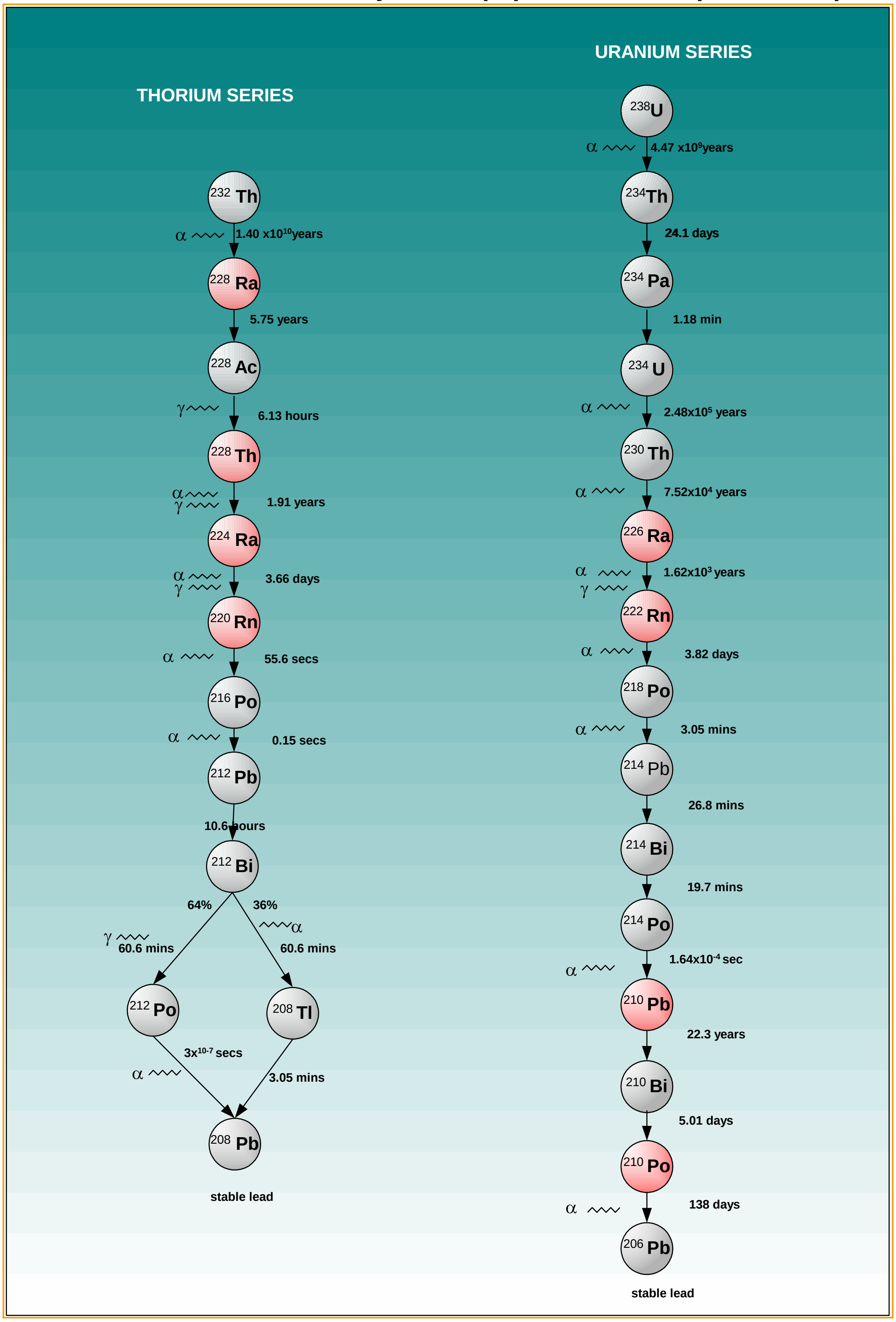
Oil and gas industries

A2.20 The oil and gas industry is an important contributor to the UK economy. In 2008, there were 266 oil and gas production platforms operating in the UK sector of the North Sea and Irish Sea. Up to 2007, these have produced 605 million barrels of oil, and 428 million barrels of oil equivalent in gas. In 2006/7, these industries provided 74% of the UK's total primary energy production and employed 320,000 people in the UK, directly or indirectly. These industries have also contributed a cumulative total of £243 billion in taxes.

A2.21 During the process of extracting oil and gas, radioactive waste is generated as a by-product. The waste is radioactive because it contains isotopes that result from the radioactive decay of uranium-238 and thorium-232. Uranium and thorium have very long half lives and have been present since the formation of the earth. As the uranium and thorium "parent" isotopes decay (see box 2.5), they generate new radioactive "daughters". Some of these "daughters" are more mobile in the environment than their "parents", and are extracted along with oil and gas from reservoirs within the earth. Both the parent and daughter isotopes are found in water and solids associated with the extraction of oil and gas and are referred to, collectively, as Naturally Occurring Radioactive Material (NORM).

A2.22 A strategy for the management of NORM Low Level Radioactive Waste arising in bulk quantities from certain industries, including those in the Oil and Gas sector, is the subject of a parallel strategy, and will not be considered further here.

Box 2.5: 238U and 232Th Decay series (reproduced with permission)



Annex 3: Waste arisings from the non-nuclear industry

General

A3.1 In 2005, Government started a process of stakeholder engagement on policy for the long term management of solid low level radioactive waste in the UK. This led to a public consultation in 2006. Throughout these processes, the non-nuclear industry stated that there was a growing trend towards fewer facilities to take their radioactive wastes. and this was giving rise to concern about future disposals. For instance, In the case of historic incineration capacity, clinical waste from the medical sector had largely been disposed of via on-site incinerators that were authorised to take radioactive waste. However, regulations relating to the incineration of hazardous waste were tightened up considerably in the 1990s, and because of the cost of upgrading incinerators to meet the new requirements, few hospitals continued to have incinerators that could be used for the disposal of clinical waste.

A3.2 Government recognised, based on this and similar intelligence, that is was necessary to collect information of current and future waste arisings, and the availability of facilities for their management.

A3.3 Waste management planning is a matter for consideration by:

- waste producers;
- waste management companies; and
- local authority planning officers.

A3.4 This planning depends to an extent on data relating to both the nature and the quantity of waste. Information covering the *nature* of waste is contained later in this Annex . Some examples of the type of wastes include:

- lightly contaminated syringes, gloves, overalls and bandages from the medical industry;
- gaseous tritium devices such as self-illuminating emergency exit signs;
- lightly contaminated glassware and surplus reagents from radioactive labelling for drug development in the research sector; and
- used microscope slides and small radioactive sources used for demonstrations within the teaching sector.

Regarding the *quantity* of waste which may arise in the future, this is more problematical. This annex sets out how Government attempted to elicit information on waste quantities. However, due to the significant uncertainties and low quantities involved, the data is far from complete. What the data elicitation exercise has revealed, however, is that the quantities of LLW arising in the non-nuclear sector are trivial by comparison with the quantities of Directive wastes from industrial, commercial and domestic sources. For this reason, the quantity element of the data requirement is not important. Waste management companies, for instance, who may be planning new facilities, do not need to adjust future landfill capacity requirements to allow for the disposal of LLW from the non-nuclear sector (except for NORM wastes, which are a consideration in the parallel LLW strategy for NORM wastes). The LLW component of future disposals will be far less than 1% of the overall waste quantities. Planning officers do not need to designate a certain proportion of landfill capacity specifically for LLW.

A3.5 Waste management companies intending to devote landfill or incineration capacity for LLW will do so on the basis of their own data collection – an essential element of their business planning and economic case. This data, when analysed, will be presented to waste planning authorities as a matter of course. It is not a function of Government to collect and analyse waste quantity data for these purposes.

Galson Sciences Ltd pilot study

A3.6 Recognising that general data would be needed to verify the urgency of what was being reported, Government commissioned a pilot study in 2006, which was to assess the feasibility of gathering various data on radioactive waste arisings (VLLW and LLW), and their disposal, from the non-nuclear industry [Ref. 12]. The study was limited to the south-east of England, and gathered data from around a third of organisations in that area holding permits. Based on this sample, annual arisings from the south-east of England were estimated at 170 tonnes of VLLW (60% by mass sent for incineration and 40% for landfill) and 250 tonnes of LLW (58% by mass sent for incineration, 24% sent to the LLWR near Drigg, 14% sent for storage or other treatment, and 4% sent for controlled burial at landfill). Incinerator residues were estimated separately, and for the study area were estimated at 4,200 tonnes per year.

A3.7 This study confirmed there were strategic threats to disposals from the non-nuclear industry, identifying these as:

- limited capacity and small number of facilities for incineration of wastes containing alpha emitting radionuclides;
- the predominance in the UK marketplace of one company in providing incineration capacity for beta/gamma bearing wastes;
- the almost complete absence of landfill sites accepting LLW for controlled burial;
- and the uncertain future and availability of the Low Level Waste Repository near Drigg.

A3.8 In recognition of views expressed during the LLW public consultation, and the findings of the pilot study, Government made a commitment to develop a waste strategy across the UK for the non-nuclear sector. It stated that this strategy would require estimation of the extent and geographical distribution of LLW arisings from the UK non-nuclear sector. In 2007, Government established the Programme Board to oversee this new study (which would extend the findings of the pilot study) and prepare recommendations for a waste strategy for the non-nuclear industry. Membership and terms of reference of the Programme Board are in Annex 9 In September 2007, the Programme Board commissioned the environmental consultancy, Atkins, to undertake UK-wide data collection on LLW and VLLW arisings from the non-nuclear industry. The findings of the Atkins project are summarised and discussed in this strategy. These data and other work have been drawn upon by the programme board to prepare recommendations for a waste strategy for the non-nuclear industry.

Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) reports on VLLW and LLW

A3.9 SNIFFER has commissioned several reports which contain information relevant to this strategy; this information is of relevance to non-nuclear waste producers throughout the UK. One project [Ref. 15] aimed to establish a framework for assessing the suitability of controlled burial of LLW. This report stated that the availability of approved sites for such LLW had declined because those that had closed had not been replaced. At that time (2005), only two landfill sites (with very limited remaining capacity) existed in Scotland that would take LLW; this remains the situation in Scotland. Although the situation in England and Wales was not as extreme, the SNIFFER report further stated that without new sites and further capacity, the current situation was not sustainable, and for the non-nuclear industry, the scattered distribution of approved sites was resulting in unnecessary transport and handling of the wastes. Regarding nuclear industry wastes, current developments indicate that landfill capacity will increase.

A3.10 A further project was undertaken for the specific purpose of assessing risk from VLLW disposals [Ref. 16]. This work identified the types of VLLW being produced, and estimated the amounts of VLLW arising from the non-nuclear industry in 2005 (but excluded oil and gas sectors), examined trends in waste management, and included an assessment of the potential impacts of exposure to VLLW during waste management and disposal. Data on risk assessments from this SNIFFER study are reproduced in this present document. The project resulted in the collection of data on VLLW arisings from about one third of environmental permit holders in the UK. The authors then used these data to estimate national annual arisings of VLLW, these being 3,600 tonnes of 'primary' VLLW and 20,000 tonnes of 'secondary' VLLW (i.e. residues arising from incinerators licensed to take LLW under EPR 2010). These SNIFFER projects provide useful guidance that non-nuclear industry waste producers can use as the basis for their submissions to the environment agencies about the disposal of solid waste.

The Atkins project

A3.11 To prepare the non-nuclear industry waste strategy, the programme board sought the following information on waste arisings:

- how much LLW and VLLW are arising from the non-nuclear sector at present (in terms of activity, mass, volume and physical form)?;
- what disposal routes or alternative management routes are available (and being used) for the LLW and VLLW?; and
- what changes are likely in terms of arisings and management facilities?

A3.12 Atkins was commissioned to collect these data from across the UK, and the main findings from this project (henceforth called the Atkins project) are summarised below. The full report and associated data file can be obtained from the DECC website [Ref.11].

A3.13 The Atkins project was undertaken between September 2007 and the following autumn. Contact details of all organisations holding RSA 93 authorisations to dispose of radioactive waste were requested from the environment agencies. Those organisations that could be contacted were asked to submit data on their LLW and VLLW waste streams using an electronic questionnaire. Submitted data were sorted as follows: sector (e.g. research, medical, industrial etc.), type of waste (LLW or VLLW), and for each waste stream reported, annual data on the specific radionuclide (or group of radionuclides), physical quantity (volume OR mass), physical form (e.g. clinical, organic liquid etc), and disposal method. These data were requested for current, historical and anticipated waste streams.

A3.14 Information was sought from the Oil and Gas sector but, as a decision was taken at that time to deal with bulk NORM wastes separately, this aspect was not pursued.

A3.15 Information on disposal facilities was extracted from the questionnaires, and further data on quantities and disposal routes for secondary VLLW (incinerator residues, being ash and lime) were sought directly from operators of identified plant.

A3.16 Of the 877 facilities that held RSA 93 authorisations, 766 were successfully contacted, just over a third of which responded to the questionnaire. However, only 172 organisations provided data on current or recent waste arisings (covering 254 waste streams) that could be analysed for the project – this represents just under 20% of all organisations that hold a permit to produce solid LLW or VLLW. This was an insufficient statistical base on which to decide if the responding organisations could be treated as representative of the remaining 80%. For this reason, and the overall low response rate, the extrapolation of the data to produce an estimate of UK arisings should be treated with caution. Nonetheless, the survey produced a number of useful indications of waste types, geographical distribution and transport issues. The main findings from the survey are summarised in the following paragraphs (and unless otherwise indicated, are data only from the survey).

A3.17 The sectors which provided useful data (split between current, historical and anticipated arisings) are shown in table 3.1. In summary, 172 organisations provided data on current waste streams, 91 on historical waste streams and 57 provided data on anticipated arisings. The medical and research sectors dominated the survey returns (and hence certain waste types and radionuclide content also dominated the data from the survey).

Table 3.1- Number of organisations providing data for different time periods[5]

Sector	Current	Historical	Anticipated
Industrial	13	6	8
Medical	70	35	27
Research	60	39	18
Teaching	4	2	1

[5] Some organisations provided data for all three time periods, others for only one or two of the time periods.

Sector	Current	Historical	Anticipated
Other	25	9	3
Total	**172**	**91**	**57**

A3.18 Data on current/recent waste streams were summed to provide overall annual volume and mass of waste6, as follows:

- The total amount of LLW per year was around 4,800 m3 plus 13 tonnes.
- The total amount of VLLW per year was around 46,500 m3 plus 41 tonnes.

A3.19 Of the total volume of LLW plus VLLW reported in the survey (approximately 50,000 m3), the medical sector was responsible for 77% and the research sector for 21%. Not surprisingly, therefore, the radioactivity in the waste was dominated by carbon-14, tritium and technetium-99m, and other short lived beta emitters, with clinical and laboratory wastes being the most commonly reported physical waste types.

A3.20 Nearly 90% of reported volumes of VLLW came from Scottish non-nuclear organisations (mainly large hospitals), but this is simply representative of the fact that more proportionally more organisations in Scotland responded to the survey. This meant that VLLW from organisations in the rest of the UK amounted to approximately 5,000 m3 per year. (One-off disposals reported in the survey amounted to 30 m^3 and were excluded from the analysed data).

A3.21 Of the total mass of LLW plus VLLW reported in the survey (around 54 tonnes), nearly 70% came from industrial and laboratory sources, and waste management services. The dominant type of radioactivity was long lived beta emitters as well as carbon-14 and tritium. (One-off disposals amounted to 3.7 tonnes, and were excluded from the analysed data).

A3.22 For wastes reported by volume, incineration was by far the most widely used method of disposal, whereas for wastes reported by mass, it was landfill, which reflects the domination of the former by clinical wastes, and of the latter by industrial wastes.

[6] Volumes and masses are not inter-related. This is because organisations could provide data as either volume or mass according to their custom and practice; few organisations provided data on both volume *and* mass. Density calculations were not applied to obtain total quantities in one or other unit, because of the many different physical waste stream types.

Table 3.2 – Annual quantities of current/recent waste arisings[7]

Type of data	cubic metres	kilograms
Disposal by incineration (VLLW and LLW)	50,183	17,776
Disposal by landfill (VLLW)	880	32,188
Disposal by controlled burial (i.e. LLW)	29	0
Disposal to LLWR at Drigg	53	270
Use of decay storage (followed by disposal as conventional waste)	60	0
Other (mainly transfer of waste to a waste treatment centre, or decay storage then incineration)	145	3,979
Total quantities (the data on volume and mass are mutually exclusive)	51,350 m^3	54,213 kg (54.2 tonnes)
Estimate of total UK arisings of non-nuclear wastes On the basis that the survey included around 20% of all authorisation holders, and that the bulk of the arisings are from one area of the UK that appeared to be well represented in the survey, it is estimated that total UK arisings from the non-nuclear industry are very unlikely to exceed 100,000 m^3 per year. In comparison, total directive waste arisings in England are around 272 million tonnesi. Non-nuclear waste arisings are therefore very unlikely to exceed 0.1% by volume of conventional use controlled to be consistent throughout waste arisings from the whole of the UK.		

A3.23 Organisations participating in the survey were asked to provide information on historical, current/recent and anticipated quantities of LLW and VLLW. Data were sorted in terms

[7] Estimates of annual arisings of LLW and VLLW from the non-nuclear industry were prepared to support the LLW policy (ref 1) – these were: 5,400 cubic metres of primary VLLW and LLW arising annually, 63% of which was incinerated, 32% sent for landfill and the rest sent to the LLWR near Drigg and to controlled burial. Secondary VLLW as incinerator residues were estimated at 42,000 cubic metres per year (but included incineration of nuclear LLW).

of radionuclide content of the wastes (e.g. long lived beta emitters, short lived beta emitters) and on volumes and masses. The results for current versus anticipated quantities of radioactivity are summarised in table 3.3. In most cases, slight increases in the radioactivity of wastes were anticipated for most radionuclide groups, although the limited number of organisations providing data for this part of the survey, as shown in the table, indicate that these estimates should be treated with a degree of caution. When physical quantities of wastes were considered, about half the volume and about a quarter of the mass were anticipated, compared to currently.

Table 3.3 - Comparison of current versus anticipated quantities of radioactivity in wastes

Description of waste		Current versus anticipated arisings
Radioactivity in waste	Wastes containing alpha emitters	Activity will increase by around 60% (data from 1 organisation)
	Wastes containing uranium	Activity will stay the same (data from 1 organisation)
	Wastes containing long lived beta emitters	Very slight increase in activity (data from 6 organisations)
	Wastes containing short lived beta emitters	Very slight increase in activity (data from 13 organisations)
	Wastes containing technetium-99m	Very slight increase in activity (data from 3 organisations)
	Wastes containing tritium	A reduction of more than 50% in activity (data from 10 organisations)
	Wastes containing carbon-14	Slight increase in activity (data from 9 organisations)
Volumes and masses of wastes		A reduction to about half the volume and a quarter of the mass (data from 57 organisations)

A3.24 Responses to the survey identified 58 disposal facilities currently being used by the non-nuclear industry (31 landfills and 27 incinerators). Only one landfill site (in England) was identified as accepting LLW for controlled burial but this was found to be an erroneous return. Many of the incinerators were connected with hospitals and laboratories, and hence burnt clinical and general laboratory waste (e.g. organic liquids, plastics gloves, needles, paper and textiles).

A3.25 Data on incinerator residues were provided from 8 operational incinerators. Current arisings totalled 261 m^3 plus 75.2 tonnes per year, all of which was sent for landfill, sometimes via waste treatment centres.

A3.26 To try and obtain information on the future provision of disposal facilities for non-nuclear industry wastes, letters were sent to a number of waste disposal companies, asking about their intentions with respect to radioactive waste. This exercise indicated that no major change in available facilities was expected, at least in the foreseeable future (but responses were very limited, possibly because commercial interests deterred some companies from responding). The Atkins report also referred to other evidence external to the survey, indicating that some waste management companies are interested in providing facilities for NDA wastes, mainly in the VLLW category, and possibly also for NORM wastes from the oil and gas sectors. Although the Atkins report mentioned only one UK incinerator that accepts alpha-contaminated wastes, it has subsequently been confirmed that a second large incinerator now has a permit to accept alpha disposals. (In principle, there are no significant technical reasons why most of the UK incineration capacity could not apply for, and receive an allowance for, an alpha component to their permit).

A3.27 To provide an overall view of the waste arisings and disposals from the non-nuclear industry across the UK, data on waste streams originating from the same Waste Planning Authorities (WPA) were assembled from the survey database. Seventy-three English and 7 Welsh WPAs had one or more non-nuclear organisations that had taken part in the survey. Scotland was treated as one WPA (and a number of Scottish organisations had provided data). The quantities of waste arising within the WPAs, and associated trends in expected quantities, have been analysed in the sustainability appraisal report [Ref. 17, 17a].

A3.28 Information was sought from waste producers, on approximate distances to disposal sites (incinerators or landfill sites) for their wastes. These data were aggregated and sorted to provide average distances for non-nuclear industry waste transportation within each WPA. The data are summarised in table 3.4. The data show that in the case of incineration, waste is transported to a greater extent than for landfill. This is to be expected, because there are fewer incinerators than landfill sites (particularly in the case of incinerators authorised to accept LLW). It is apparent that most radioactive wastes arising in Scotland have to be transported to England for disposal, as Scotland is virtually without disposal facilities (particularly commercial incinerators) accepting LLW (incinerators taking VLLW do not require authorisation under RSA 93 and therefore will not be identified as specifically available for VLLW). The shortage of disposal facilities taking radioactive waste in Scotland has been identified in other work [Ref. 15].

Table 3.4 – summary of average 'waste miles' to disposal sites from each WPA

Transportation of waste (in bands of waste miles)	Waste for incineration	Waste for landfill
Less than or equal to 25 miles	23 WPAs	28 WPAs
Between 25 and 50 miles	12 WPAs	1 WPA
Between 51 and 100 miles	18 WPAs	2 WPAs
Between 100 and 300 miles	6 WPAs	1 WPAs
Total number of WPAs for which 'waste mile' data were analysed	59 WPAs	32 WPAs

A3.29 Organisations that had provided useful data were invited to answer questions designed to identify factors influencing their choice of disposal route, and to determine to what extent the principle of proximity applies to the overall pattern of disposals across the UK. A total of 185 facilities were contacted and 32 responses received. These responses were supplemented by interchanges facilities by non-nuclear industry liaison groups run by the environment agencies.

A3.30 The following are the main findings from this qualitative exercise:

- The majority of responses (22) stated they had not experienced any problems in disposing of their wastes. The other responses indicated that although there appeared to be a perception that waste routes are not as numerous as previously, the main problems seemed to be practical, concerning the setting up of contracts and obtaining relevant permits from the environmental regulators.

- When asked about the influence of the 2007 LLW policy on their own waste management, most facilities stated they had not been affected so far (although the new policy was welcomed by some).

- Costs, availability and historical arrangements are the factors which appear to predominate in the selection of waste routes, although there were some indications that the 2007 LLW policy was being noted.

A3.31 It should be noted that all permit holders are required to provide the environment agencies with records of their waste disposals. In the case of LLW, this requirement covers the amount (becquerels per year), types of radioactivity (alpha emitters, short lived beta emitters etc.) and disposal routes, but similar data are not required for low volume VLLW disposals (i.e. covering most non-nuclear disposals of waste in this category, which are generally exempt). No requirement is placed on organisations to report physical quantities of either LLW or VLLW, even though these wastes are disposed of to facilities taking Directive wastes, which are normally defined in terms of volume and/or mass.

A3.32 In view of the current mismatch of information between what is routinely collected by the environment agencies from the non-nuclear industry, and the information usually required for waste strategies on other wastes, Atkins was also required to advise the programme board on how data collection from the non-nuclear industry could be improved on a routine basis. If the databases holding information on the non-nuclear sector could be improved, the waste strategy could then be updated from time-to-time without the need for costly one-off surveys. It was for this reason, that Atkins designed an electronic survey form for the project – the idea being that it, or a similar form, could easily then be adapted for routine use.

A3.33 The limited response to the electronic survey and difficulties experienced by those using it, as well as the qualitative responses to the later questionnaire led Atkins to question whether routine data collection beyond the current requirements is justified. Other arguments were that considerable improvements would be needed to one of the environment agencies' databases and that legal enforcement would be needed to induce the majority of facilities to provide additional data on their wastes on a routine basis, which would need justification.

A3.34 Northern Ireland waste producers only generate very small annual quantities of LLW and/or VLLW (It is estimated that around 6 m^3 per year of radioactive waste from Northern Irish non-nuclear industries (mainly hospitals) are sent to Great Britain for incineration. Apart from one incinerator which accepts some clinical wastes, all other waste is exported to the mainland for incineration or landfill. Although (without further evidence) this appears to contradict the principle of proximity, it seems unlikely that the small volumes of such waste would encourage commercial waste disposal operators to enter the market in Northern Ireland.

A3.35 The Ministry of Defence has a number of sites producing LLW and VLLW that fall within the definition of the non-nuclear sector. However, the MoD was unable to provide a full set of quantitative data within the timeframe required by the project.

A3.36 The decision by the programme board to introduce work on sustainability appraisal of the strategy meant that some data collection originally intended for the Atkins project (particularly on available waste disposal capacity) was undertaken by this separate exercise, and is reported in the scoping report on sustainability appraisal [Ref. 17, 17a].

A3.37 The Atkins project provided an opportunity for non-nuclear organisations to contribute useful data for the development of a UK strategy specifically for their wastes. The role of the survey in the development of the strategy was made clear in the early information sent to organisations, and therefore the response rate to the main survey was rather less than anticipated. Additionally, those who provided data appeared to be managing to find disposal routes for their solid radioactive wastes. For these reasons, the Atkins report recommended that the strategy (and any future data collection initiative) should concentrate on the longer term rather than the immediate future.

A3.38 The quantities of waste arising from the non-nuclear sector suggested by the Atkins project are somewhat at odds with previous estimates. For example, the sample from the survey suggested nearly 55,000 m3 per year of primary LLW and VLLW, whereas the previous estimate [Ref. 12] was for less than 6,000 m3 per year for the whole of the UK. This wide discrepancy may be partly due to survey responses being heavily influenced by data from Scottish organisations which make up nearly 90% of the total VLLW volume. However, it should be pointed out that previous estimates of UK arisings from the non-nuclear sector have also been based on very limited data, and in one study [Ref. 12] based on only one part of the UK, and are therefore also likely to be considerably in error when used to extrapolate to a UK-wide position. Nonetheless, the Atkins project has provided broadly indicative information on the geographical distribution of waste arisings, disposal routes and physical descriptions of the wastes, all of which are useful data for the strategy and for waste planning authorities. An estimate of 100,000 m^3 per year of LLW and VLLW arising from the UK non-nuclear sector has been made, based on the data, but, this figure should be treated with caution.

A3.39 Except possibly for carbon-14 and tritium, there appears to be no significant anticipated increase in most types of radioactivity in wastes that will require disposal from the non-nuclear sector. Anticipated physical quantities are less than at present.

A3.40 Controlled burial of LLW by the non-nuclear sector appears to be very rarely undertaken, despite its inclusion amongst disposal options in the 2007 LLW policy statement. It is not possible to determine the relative split between incineration and landfill of LLW and VLLW (because of the mixed reporting of volumes and masses of waste). However, using very rough estimates of densities of waste, it appears that the bulk of primary LLW and VLLW is probably sent for incineration. Data on secondary VLLW (i.e. incinerator residues) were very sparse, as few incinerator companies responded to Atkins' request for information. However, the Environment Agency is currently updating information on the incineration of radioactive waste July 2011).

A3.41 The scoping report on sustainability appraisal of the waste strategy also has drawn upon data from the Atkins project.

Contaminated land

A3.42 The UK has a legacy of contaminated soil, some of which contains above-background concentrations of certain naturally occurring radionuclides. This contamination has resulted from past industrial activities that pre-date the proper control of the use and disposal of radioactive wastes. An example is the processing of uranium ore by a number of businesses during the 1940s and 50s, to extract radium which was then incorporated into paint and used to illuminate aircraft dials, watches and other products.

When these businesses ceased to exist, they often left behind soil contaminated by radionuclides in the natural decay chains of uranium and thorium, the most significant of which is radium. Where such contaminated soil presents significant risks to people (defined as greater than 3 millisieverts per year), the land may be determined as "contaminated land" in the Environmental Protection Act 1990.

A3.43 The Government's long-term aim is to work towards a future where all the contaminated land presenting significant risks in the UK has been identified and dealt with. Some land is voluntarily remediated (for example, in cases where land is being redeveloped under the planning system, or because land owners want to increase the utility and value of their land). However, legislation under Part 2A of the Environmental Protection Act 1990 has been developed to cover situations where the contamination presents significant risks and there is unlikely to be a voluntary solution. Examples could be contaminated sites which have been developed without being cleaned-up and sites where the person who polluted the land, and/or the current owner, is unwilling to deal with the problem voluntarily. The scale of the remediation and who is responsible for carrying out the actual work, depend on the circumstances of each case.

A3.44 In cases of change of use of land, if this is covered by the planning system, it is the responsibility of planning authorities to ensure that the contamination is dealt with through the planning system, and that remediation takes place where required. If remediation results in the generation of radioactive waste, a permit issued by the environment agencies under radioactive waste legislation would be required, to accumulate or dispose of the waste. Depending on the level of contamination of soil, disposals may be to landfills used for conventional (controlled) wastes.

A3.45 Whilst they are potentially significant in terms of volumes, the ad hoc nature of arisings from remediation of land contaminated with radioactivity does not allow for long term planning for disposal of associated soils etc. This non-nuclear strategy does not therefore include any requirements on planning authorities to make specific provision within their planning frameworks. There does not seem to be any reasonable alternative to the present position, which is that each case should be dealt with by the affected planning authorities and the environment agencies as it arises. However, it would be prudent for waste planning authorities to make reference in their planning documents to the possibility that contaminated land might arise in their area, and that some disposals of contaminated soil might be required within local landfills.

A3.46 The majority of radioactive waste in the LLW category is high volume NORM waste' for this reason, the parallel strategy for NORM wastes will explore this issue further.

Spent sealed sources

A3.47 Radioactive sealed sources (i.e. where the radioactivity is contained in a welded metal capsule) are used for a wide variety of purposes by the non-nuclear industry. They range from very high activity sources comprising energetic gamma emitters (for example as used in radiotherapy and industrial radiography) down to low activity sources comprising alpha or weak beta emitters (for example, as used in smoke detectors and illuminated signs). Once the source has reached the end of its design life, or is no longer required, it requires disposal.

A3.48 Some very low activity sources fall within the exemptions regime under radioactive substances legislation (for example exemptions covering smoke detectors and testing instruments) and can be disposed of with municipal/industrial wastes to landfill or incineration. Some spent sealed sources can be recycled at specialised facilities, where the radioactivity is recovered for another use. All other sealed sources require either to be disposed of as LLW that has to go to the LLWR near Drigg, or storage as intermediate level waste (ILW) at Sellafield or Harwell (ILW has no disposal route at present).

A3.49 Many public sector organisations that had been using sealed sources for a long time, had resorted to simply storing them, because they could not afford to dispose of them. The Government was concerned about the security implications of this practice, and in 2004, provided over £7 million for a subsidised disposal campaign, the Surplus Sources Disposal Programme (SSDP). This programme of disposal has now largely been completed, and was highly successful as it resulted in the collection of many thousands of small spent sources from hospitals, universities, schools, colleges, museums and other organisations. Some large sources were also safely disposed of as a result of the SSDP.

A3.50 Since 2005, certain types of higher activity sources fall under the High Activity Sealed Radioactivity Sources and Orphan Sources (HASS) Regulations 2005. These regulations place additional requirements on users to those in previous authorisations issued under the RSA 93. In particular, they require those wishing to use HASS sources to register them with the environment agencies, and demonstrate suitable security arrangements for their storage and use. They must also make financial provision for their disposal prior to their purchase. However, the majority of sealed sources used by the non-nuclear industry do not fall under the definition of those covered by the HASS Regulations, and each user must make arrangements for their disposal. With the imminent completion of the SSDP, the environment agencies will ensure that the disposal of all sources is adequately addressed by users, before they purchase them. Nonetheless, in the case of spent higher activity sources that cannot be disposed of to the LLWR near Drigg (or any replacement), the UK will continue to require a facility for their treatment and/or storage, until permanent disposal facilities are available for ILW. Up to now, storage has been undertaken in facilities operated under contract from the NDA at Sellafield or Harwell.

Annex 4: Radioactivity and Radiation Dose

Radioactivity

A4.1 Radioactivity is the property of unstable atoms to undergo transformation with the emission of radiation. The unit of radioactivity is the becquerel (Bq), but radioactivity is usually expressed as Bq per unit mass and in the case of solid waste, as Bq per gram, or per tonne. The Bq is equal to one radioactive transformation per second. Multiples of the Bq are commonly used:

- Kilobecquerels (kBq) = one thousand Bq
- Megabecquerels (MBq) = one million Bq
- Gigabecquerels (GBq) = one thousand million Bq.

A4.2 Radioactive atoms (called radionuclides or radioisotopes) occur both naturally and artificially. Some, particularly those that are naturally occurring, are part of long decay chains (for example, isotopes of uranium and radium), but all eventually decay to non-radioactive atoms. The rate of decay is unique to each radionuclide and is usually defined according to the half-life; this is the time required for one half of the atoms of a given amount of a particular radionuclide to disintegrate. Half-lives vary from fractions of a second through to many millions of years. The existence of naturally occurring radionuclides of extremely long half lives, together with decay chains, means that virtually all material on the earth is radioactive to some extent. Natural radioactivity is also created by processes in the upper atmosphere.

A4.3 The type of radiation emitted by radionuclides (mainly alpha or beta particles and gamma rays) is called ionising radiation because it removes electrons from atoms, leaving them unstable. Ionising radiation loses energy as it passes through matter, and when it interacts with living tissue, the ionisation it causes may lead to changed or damaged cells. This can result in deterministic effects (immediate damage to tissue) or stochastic effects (usually the development of a cancer over a period of time).

Radiation Dose

A4.4 A radiation dose is defined as the energy absorbed per unit mass of material through which it passes. The unit of dose is the gray (Gy) but when dose to living tissue is involved, the unit sievert (Sv) is used. The Sv is a very large amount of radiation dose, and so sub-multiples of the Sv are more commonly used, for example;

- millisieverts (mSv) = one thousandth of a sievert, or
- microsieverts (µSv) = one millionth of a sievert.

A4.5 People are exposed to radiation simply as a consequence of living in a naturally radioactive world. The average dose from natural sources of radioactivity to members of the public in the UK is 2.2 mSv (i.e. 2,200 µSv) per year. However, the property of radioactivity is also used to diagnose medical conditions (with radioactive tracers) and treat disease (by killing malignant cells). It is also used to carry out research, and these activities usually create wastes containing small quantities of radioactivity that require disposal. Exposures of members of the public to the radioactive wastes arising from medical and other uses of radioactivity by the non-nuclear industry are generally in the range of a few µSv or less per year, i.e. around one thousandth of the natural background radiation dose.

A4.6 Investigation into the effects of radiation on humans has been considerable and spans at least 60 years, covering actual exposures of people to natural sources of radiation (e.g. uranium miners) and artificial sources (e.g. people treated with radiation for various medical conditions and more recently, large studies of the health of radiation workers). The long-term effects of these real-life human exposures have been considered alongside a vast number of animal and cell experiments. The bulk of evidence points to a linear relationship between exposure and effect, without a threshold (that is, the greater the exposure, the greater the effect). In the UK, radiation exposure that is imposed upon the public over and above natural background is subject to regulation, based upon European standards and international recommendations on radiological protection.

Annex 5: Regulatory Framework

Principles of radiation protection

A5.1 The systems of radiation protection used in many countries of the world, including the UK, are based on the recommendations of the International Commission on Radiological Protection (ICRP). ICRP is a non-governmental scientific organisation which publishes recommendations for protection against ionising radiation. ICRP's recommendations have been incorporated into European Law through Council Directive 96/29/Euratom [Ref. 18], laying down basic safety standards for the protection of the health of workers and the general public against the dangers from ionising radiation. ICRP's most recent recommendations [Ref. 19] have yet to be incorporated into EU law, but the basic principles of radiological protection are unchanged, and are:

- **Justification:** in relation to a practice, any decision that alters the radiation exposure situation should do more good than harm;
- **Optimisation of protection:** the likelihood of incurring exposure, the number of people exposed, and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors;
- **Dose limitation:** the total dose to any individual from regulated sources in planned exposure situations other than medical exposure of patients should not exceed the appropriate limits recommended by the Commission.

A5.2 It should be noted that the justification principle relates to the practice giving rise to the waste, and not to subsequent waste management. However, both of the other two principles, optimisation of protection and dose limitation, do apply directly to waste management.

Regulation of Radioactive Waste Disposal

A5.3 The disposal of radioactive waste on or from premises in the UK is subject to regulation.

- In England and Wales, this regulation is provided for through the Environmental Permitting Regulations 2010 (EPR 2010).
- In Scotland and Northern Ireland regulation is provided via the Radioactive Substances Act 1993 (RSA 93).

A5.4 These regulations provide the framework for controlling the management of radioactive wastes so as to protect the public and the environment. The different legislation used in different parts of the UK does not change the environmental standards for radioactive substances. In order to simplify the description of applicable regulations, throughout this strategy EPR 10 and RSA 93 are collectively be referred to as the 'radioactive waste regulations'. Furthermore, throughout this strategy, references to a 'permit' mean a permit to dispose of radioactive waste under EPR 10 for England and Wales, and/or authorisation to dispose of radioactive waste under RSA 93 in Scotland or Northern Ireland.

A5.5 The environmental regulators responsible for the regulation of radioactive substances are the Environment Agency in England and Wales; the Scottish Environment Protection Agency (SEPA) in Scotland; and the Department of the Environment's Northern Ireland Environment Agency (NIEA). The EA is therefore responsible for enforcement of EPR 10 and SEPA/ DoENI are responsible for RSA 93 in Scotland and Northern Ireland respectively.

Exemptions from regulation

A5.6 All materials are radioactive to some extent (see Annex 4). There is some waste which is not required to be subject to specific regulatory control, because the levels of radioactivity contained within it are either not possible to control, or are so low that full regulation (including permitting and regular inspection) is not warranted. Such wastes may be disposed of in the same manner as other municipal, commercial and industrial wastes i.e. to landfill and incineration, without permits under radioactive waste legislation.

A5.7 Where radioactive waste is exempt from requiring an environmental permit as a radioactive substance under the radioactive waste regulations, it is subject to hazardous waste controls in the Hazardous Waste (England and Wales) Regulations 2005, as amended, if it has one or more hazardous properties arising, other than from its radioactive nature. When radioactive waste requires a permit as a radioactive substance under the radioactive waste regulations but has one or more hazardous properties, it is not covered by hazardous waste controls.

Application of the Radioactive Waste Regulations to the Non-nuclear Industry

A5.8 Unless covered by an exemption provision, before organisations can keep or use radioactive materials, they need a permit under the radioactive waste regulations. If the radioactive materials will generate or become waste then the permit will also cover accumulation and disposal of waste.

A5.9 Applications to keep and use radioactive materials, or accumulate and dispose of radioactive waste, should be sent to the relevant environment agencies. Details on how to do this, the forms needed and how much it costs, are provided on each of the environment agencies' websites [Ref. 20]. For some sources an inspection by the relevant environment agency and a Counter Terrorist Security Advisor from the relevant police force may be required before a permit can be issued. The radioactive waste regulations allow the environment agencies up to 4 months to issue a permit.

A5.10 It is the applicant's responsibility to identify disposal routes for their waste. The environment agencies do not advise on specific companies that may deal with waste, but will consider the different options that are available when deciding whether to grant a permit. Applicants are also required to provide a risk assessment when applying for a new permit or a variation to an existing permit. The level of detail in the application should be proportionate to the potential doses to members of the public and the population as a whole. Guidance is available on the regulators' websites.

A5.11 In England and Wales, the Environment Agency consults with the Food Standards Agency prior to issuing environmental permits/ authorisations. Similar arrangements apply in Scotland.

A5.12 The relevant environment agency inspects premises where radioactive waste is accumulated or disposed from. The frequency of inspection depends on the environmental and security risk the site poses.

A5.13 Each environment agency has an enforcement and prosecution policy which determines what action to take if an authorisation condition is breached. Enforcement action can include: prosecution, formal caution, warning letter or an on-site warning. In addition, to ensure compliance or prevent harm, the environment agencies can serve enforcement and prohibition notices. (In Scotland, the procurator fiscal, and not SEPA, issues cautions and carries out prosecutions).

A5.14 Holders of permits (and users of exemption provisions) must keep records of the waste they produce and dispose of. In the case of permit holders, these records are inspected by environment agencies' officers when they check compliance against conditions. The environment agencies also require all holders of permits for radioactive waste to provide an annual report of the waste they have produced and how it was disposed of.

A5.15 Whilst disposal records for exempt wastes, including VLLW are not required to be sent to the environment agencies, waste producers still need to be able to demonstrate compliance with exemption conditions, and therefore should keep their own records of such disposals.

Currently permitted disposal options for radioactive waste from the non-nuclear industry

A5.16 Historically, incineration, landfill, and use of the Low Level Waste Repository near Drigg (LLWR) have been used by the non-nuclear industry for disposal of its solid low level radioactive waste. The LLW policy statement on the long term management of solid LLW has confirmed that these disposal options continue to be amongst those that may be considered for the disposal of the wide spectrum of waste types and activity concentrations within LLW in the UK [Ref.1].

A5.17 In implementing the 2007 LLW policy, both the Environment Agency and SEPA have decided that any new permits for disposal of non-exempt LLW to landfill will be issued to the landfill site, as well as to the waste producer. In January 2009, the Environment Agency published guidance and briefing notes on the disposal of radioactive waste to landfill in England and Wales [Ref.3].

A5.18 The developers and operators of near-surface facilities for solid radioactive waste disposal (i.e. low level waste repositories or landfill sites that could take LLW) have to demonstrate to the regulators that the facilities will adequately protect people and the environment. To do this, they will need to show their approach to developing and operating the facilities, and also demonstrate that the location, design, construction, operation and closure of the facilities, will meet a series of principles and requirements. The environment agencies have published guidance, called Guidance on Requirements for Authorisation, GRA [Ref. 21], which sets out these principles and requirements, and which indicates how they are likely to be interpreted. The guidance also provides information about the associated framework of legislation, government policy and international obligations.

A5.19 The Health Protection Agency (HPA) has published advice on the land-based disposal of solid radioactive waste [Ref. 22]. This advice is intended for the detailed risk assessment of solid radioactive waste disposal facilities at the planning stage. It applies to all types of disposal facilities for solid radioactive waste management, ranging from purpose-built facilities near-surface and deep underground, to existing landfill sites that accept small quantities of low level or very low level radioactive waste. The advice primarily focuses on the situation after a facility has closed rather than the operational period when it is receiving waste for disposal.

A5.20 Incinerators that burn LLW must have a permit to do so under the radioactive waste regulations, whilst those that burn VLLW do not. In practice, premises that produce both combustible LLW and VLLW will often send both types of waste to permitted incinerators. The radioactive waste is usually mixed at the incinerator premises with much larger amounts of other wastes (i.e. directive waste, including non-radioactive clinical wastes which must be incinerated).

A5.21 Incineration leads to a reduction in waste mass and volume of up to 90% and results in the creation of residual ash and air pollution control residues. Due to the dilution of radioactive wastes by other wastes in the incineration process, these residues can usually be disposed of as non-radioactive waste or, in some few cases, VLLW. That is, waste ash will almost always be disposed of without the need for a permit under radioactive waste legislation (although other waste permitting requirements will obviously apply to such disposals).

Annex 6: Assessment of risk from disposals of non-nuclear industry radioactive waste

Introduction

A6.1 Only the radiological risks associated with VLLW and LLW disposals are considered in this document. Whether the waste goes for incineration, or directly to landfill depends on its non-radioactive properties. Hence, if it is combustible and/or clinical, it will usually go for incineration. Otherwise, it will usually go directly to a landfill type that is appropriate to its physical form.

A6.2 The risk of health effects to people from the disposal of VLLW and LLW from the non-nuclear industry are very low, being of the order of one in a million per year or less. The demonstration of these low risks is through the study of possible ways in which people could receive a radiation dose from the radioactivity present in the waste, called 'potential exposure scenarios'.

Estimating doses using potential exposure scenarios

A6.3 Radiation exposure can result from;

- external irradiation from radioactivity that is outside the body, called 'external radiation exposure', mostly from gamma-ray emitting radionuclides;
- inhaling radionuclides in air; and/or
- ingesting radionuclides present in water, food, or dust particles, called 'internal radiation exposure', which can arise from any type of radiation.

A6.4 The assessment of potential radiation doses to people from disposals of LLW and VLLW starts with a study of possible sources of external and internal exposure, using theoretical scenarios covering both those who work in the waste industry, and members of the public, including children (see table 6.1).The purpose of using scenarios to undertake dose assessments is to calculate maximum theoretical doses. In reality, the majority of people living close to waste disposal facilities will receive very small doses as a result of these waste disposals.

Table 6.1: Theoretical scenarios used in the assessment of doses from radioactive waste disposals

	Scenario	Radiation Exposure Route
Workers	Handling VLLW along with other non-radioactive waste, at waste transfer stations, composting and recycling facilities, landfills and incinerators.	• Direct radiation • Inhalation and ingestion of dust particles
Workers	Working at a landfill site or incinerator accepting LLW and/or VLLW	• Direct radiation from standing close to waste items containing gamma-emitting radionuclides • Inhalation and ingestion of dust particles • At landfill sites, some radioactive gases may also be inhaled.
Members of the Public	Combustion of VLLW and LLW at incinerators, and discharge of some radioactivity to air and water	• Direct radiation • Inhalation of radioactive gases • Deposition of radioactivity on the ground, or into water, followed by ingestion via food and/or water
Members of the Public	Disposal of ash and incinerator residues from incinerators to landfill, and dispersal of radioactivity into the environment via leachate	• Direct radiation from standing close to waste items containing gamma-emitting radionuclides
Members of the Public	Some incinerator residues may be reused (e.g. in construction) or recycled (e.g. in the chemicals industry)	• Inhalation of dust • Ingestion of radioactivity • via water or food
Members of the Public	Inadvertent excavation of a landfill site used for VLLW or LLW many years after closure	• Direct radiation from standing close to waste items containing gamma-emitting radionuclides • Inhalation and ingestion of dust particles • Some radioactive gases may also be inhaled.

Potential exposure of workers

A6.5 VLLW and LLW are usually physically indistinguishable from other non-radioactive waste. As the radiological risk from low volume VLLW is so low, no specific precautions are taken on account of its radioactivity. Hence, workers may handle low volume VLLW from time to time, along with non-radioactive waste, at waste transfer stations, composting and recycling facilities, landfills and non-authorised incinerators where VLLW may be received. In contrast, non-exempt LLW is labelled as radioactive waste when it leaves the premises at which it has arisen, and it does not pass through waste sorting and handling stations used for Directive waste.

A6.6 Potential exposure scenarios for workers from VLLW and LLW disposals are direct radiation exposure from standing close to waste items containing gamma-emitting radionuclides, and internal exposure from inhalation and ingestion of dust created by site operations. Some radioactive gases may also be inhaled by workers at a landfill site. These gases are produced from biodegradable wastes containing certain radioisotopes, in particular tritium (H-3) and carbon-14. The radioactive gas, radon, may also diffuse from a landfill site, and be inhaled by workers. Radon gas is part of the natural decay chains of uranium and thorium. Small quantities of uranium and thorium, and their daughter products may be present in some radioactive waste.

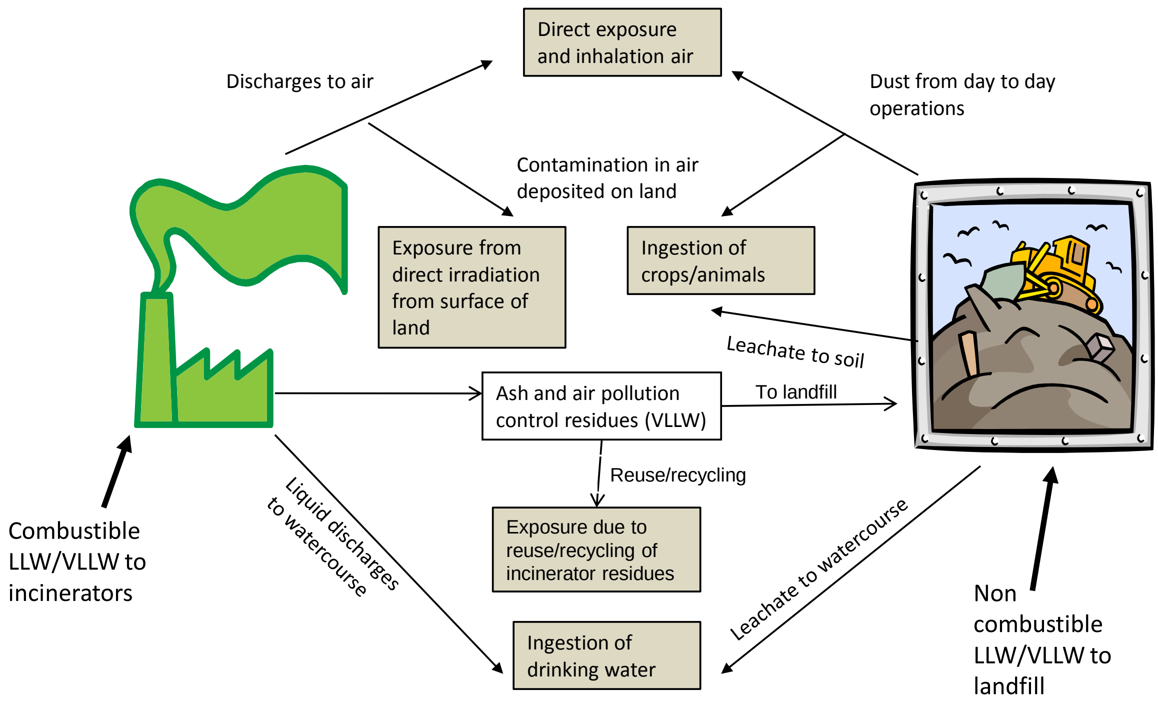
Potential exposure of the public

A6.7 Members of the public may be exposed to very small amounts of radiation because of the operation of incinerators and landfill sites that dispose of VLLW and/or LLW (see figure 1). Combustion of the waste at an incinerator results in some of the radioactivity being emitted as gases (called incinerator flue gases). Air pollution from incinerator gases, including some radionuclides, is reduced by passing them through cleaning systems (called scrubbers). These scrubbers remove most radionuclides. However, the most volatile radionuclides are not removed and are dispersed into the environment via the incinerator stacks. Very small amounts of discharged radionuclides may then be breathed in, or may be deposited onto the surface of water bodies used as drinking supplies, or onto fields and crops. The least volatile of the radionuclides mostly remain in the ash left behind after combustion, or are retained by the cleaning systems.

A6.8 Most disposal of ash and the residues arising from the cleaning systems or air pollution controls (lime, bicarbonate and sludge) is to landfill. Once the waste is in a landfill, potential exposure scenarios for members of the public are similar to those arising from direct disposal of VLLW and LLW to landfill. These exposures may occur both at the time of waste disposal, and later, including the period after the site has closed and any barriers between the waste and the environment have deteriorated. At landfills, the key engineered barriers are the liner and the cap. The liner delays the movement of leachate from the site, and hence allows time for degradation of the initial wastes. Once a landfill liner has started to degrade (a process that takes many years), it may result in leachate reaching groundwater. Leachate could also discharge to a spring, river or lake. Degradation of a landfill cap may not lead directly to exposure, but will allow more water to infiltrate into the facility and then potentially overflow into the surrounding soils. Once a landfill has ceased to be under control, at some time in the future the cap and the underlying waste could theoretically be excavated by people who are unaware of the existence of the landfill. Potential exposure scenarios from such ‘inadvertent intrusion’ could therefore be similar to those considered during the operation and closure of a known site.

A6.9 It is also feasible that very small doses of radiation may be received as a result of some VLLW ending up in reused or recycled materials, for examples plastics, or building materials that include some incinerator residues.

Figure 1: disposal of solid LLW and VLLW, and potential exposure scenarios



The calculation of radiation doses from potential exposure scenarios[8]

A6.10 Predictive models are used to assess potential exposure scenarios resulting from disposal practices (for further information on the modelling of doses from solid radioactive waste disposal to landfills and incinerators, see Ref. 16). In the case of discharges into the air from incinerators, the models are used to calculate the concentration of radioactivity in air, and deposition on land, as a function of distance from the stack. This enables calculation of potential exposures from inhaling the air, and from consuming contaminated food and water. In the case of landfill disposals, the models are used to calculate the amount of radioactivity that may arise in evolved gas and leachate as a function of time, and then, in the case of leachate, the concentrations in potential drinking water or food. The models have been developed over many years, using data from both environmental and laboratory studies.

A6.11 The environmental models are set up to take account of how much radioactivity present in the original waste is likely to reach the environment. Many of the radionuclides present in non-nuclear low volume VLLW and LLW are of short half life (see examples in table 6.1) and will have decayed away to negligible levels well before material containing it reaches the environment. The models also include data on the behaviour in the environment of each element, because this affects how soon, and how much radioactivity might end up in air, on the land, in drinking water, and in different types of food.

A6.12 Once theoretical concentrations of radioactivity have been calculated for the surface of land, in air, and in drinking water and food, assumptions are made about the habits of potentially exposed people (i.e. where they spend their time in relation to contaminated land, and air, and how much locally grown food and water they consume). These assumptions are based on the selection of conservative data from surveys of the habits of real people. That is, it is assumed that potentially exposed people will have well above-average occupancies of contaminated land, and consumption rates for food and water.

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[8] The Environment Agency is currently reviewing methods of calculating radiation doses from the incineration of radioactive waste, and will be obtaining information on the volume and radionuclide content of the waste, and associated incineration practices. Specifically, the project aims to: derive improved parameters for calculation of doses arising from radioactive substances disposed of via incineration; review partitioning and abatement factors in incinerators and perform more realistic dose calculations of doses arising from radioactive substances disposed of via incineration.

Table 6.1: Examples of radioisotopes found in waste arising from the non-nuclear industry

(A = of artificial origin; N = of natural origin)

Radionuclide	Origin	Half life	Type of emitted radioactivity
Americium-241	A	458 years	Alpha particles and gamma rays
Caesium-137	A	30 years	Beta particles and gamma rays
Calcium-45	A	165 days	Beta particles
Carbon-14	A+N	5760 years	Beta particle
Chromium-51	A	27.8 days	Gamma rays
Cobalt-60	A	5.26 years	Beta particle and gamma rays
Fluorine-18	A	110 minutes	Gamma rays
Indium-111	A	2.8 days	Gamma rays
Iodine-123	A	13 hours	Gamma rays
Iodine-125	A	60 days	Gamma rays
Iodine-131	A	8 days	Beta particles and gamma rays
Iron-55	A	2.7 years	Gamma rays
Lead-210	N	22.3 years	Beta particles and gamma rays
Phosphorous-32	A	14.3 days	Beta particle
Phosphorous-33	A	25 days	Beta particle

Radionuclide	Origin	Half life	Type of emitted radioactivity
Plutonium-241	A	14.4 years	Beta particle
Polonium-210	N	138 days	Alpha particle
Radium-226	N	1620 years	Alpha particles and gamma rays
Radium-228	N	5.75 years	Beta particle
Radon-222 (gas)	N	4 days	Alpha particle and gamma rays
Rubidium-86	A	18.7 years	Beta particles and gamma rays
Strontium-89	A	51 days	Beta particles
Sulphur-35	A	87 days	Beta particle
Technetium-99m	A	6 hours	Gamma rays
Thallium-201	A	73 hours	Gamma rays
Thorium-232	N	14 billion years	Alpha particles
Tritium (H-3)	A+N	12.26 years	Beta particle
Uranium-238	N	4.5 billion years	Alpha particles
Yttrium-90	A	64 hours	Beta particle

A6.13 The dose from inhaled and/or ingested radioactivity is calculated using factors called dose coefficients; in effect these are factors which express radiation dose (in sieverts, Sv) per unit intake (in becquerels, Bq). Dose coefficients for each radionuclide take account of the type of emitted radiation, its half life and its behaviour in the body (where it goes and how long it stays), and are age-specific. Dose coefficients for different radionuclides therefore can have very different values; for example, for polonium-210 (an alpha emitter) , it is nearly 9 microsieverts per Bq ingested (i.e. 8.8x10-6 Sv per Bq) in the case of a one-year old child, whilst for tritium (H-3 - a soft beta emitter), the dose coefficient is around half a million times less (i.e. 1.8x10-11 Sv per Bq) if ingested as tritiated water by an adult. These data are derived from a large body of experimental data, and are reviewed and revised from time to time by international experts, as new information becomes available. The lists within the BSS Directive 96/29/Euratom are mainly used in the UK, and these in turn are based on values published by ICRP.

A6.14 As well as incorporating conservative assumptions regarding habits, the models used to estimate potential radiation doses to workers and members of the public from VLLW and LLW are based on maximum radioactive inventories of the waste that are disposed. For example, in estimating annual doses from landfilling of VLLW, it is assumed that each radionuclide that could be present in VLLW, is at the maximum amount allowed within the definition of VLLW. Also, the potential doses from a landfill containing VLLW are assessed assuming all the VLLW produced in the UK per year is sent to a single landfill. In reality, the VLLW from across the UK is distributed to a number of landfill sites. Box 6.1 summarises the steps involved in carrying out a dose assessment from radioactive waste disposals.

Controlled burial (special precautions burial) of Low Level Waste

A6.15 LLW from non-nuclear industries may be disposed of to landfills, along with other non-radioactive waste, under environmental permits issued by the environment agencies. These environmental permits differ from those for VLLW because they stipulate additional conditions for disposal. The designation of landfills suitable for LLW is based on the concept of radiological capacity, that is, how much radioactivity can be consigned to a landfill such that radiation doses to people are very unlikely to exceed a dose of 10 microsieverts per year (the latter is called a dose constraint, on the basis that the environment agencies regard the practice of landfilling such material to be constrained by this level of dose). In this approach, instead of calculating the dose from an assumed amount of radioactivity present in a landfill site, a “back calculation” is undertaken, in which peak doses to workers and the public from a wide range of potential exposure scenarios are compared with the dose constraint, and then disposal limits for categories of different radionuclides are derived [Ref. 16]. To ensure that the radiological capacity of such a landfill is not exceeded, one of the environmental permit conditions is that records should be kept by the landfill operator of what LLW has already been received by the site. The methodology for calculating radiological capacities includes assumptions about other potential disposals of radioactivity to the site being assessed, in particular from wastes that are exempt from the requirements of an authorisation, and VLLW (which may go to an unspecified landfill).

Box 6.1: Modelling radiation doses from radioactive waste disposals

Stage 1: Calculate theoretical environmental contamination from disposals

(concentrations of each radionuclide on land, in air, water and foodstuffs)

Stage 2: Assess potential exposure scenarios

(how much time potentially exposed people might spend on contaminated land, how much air they may breathe, and how much water and food they may consume)

Stage 3a: Calculate potential intake of radioactivity

(in Bq from breathing air, drinking water and eating food)

Stage 3b: Calculate potential doses from direct irradiation

(due to time spent on contaminated land)

Stage 4: Calculate radiation dose from inhaled and ingested radioactivity

(using total intake of each radionuclide and its published dose-per-unit intake factor (dose coefficient)

Stage 5: Calculate total dose to potentially exposed people

(i.e. add up radiation doses from external and internal exposure)

(microsieverts per year)

NB: Due to the conservatisms built into the models, it is highly unlikely that people actually receive the assessed doses. It is also unlikely that all the possible exposure pathways would apply to a single group of people.

A6.16 The latest assessments of worker and public doses from LLW and VLLW disposal to incinerators and to landfill are all less than 10 microsieverts.

A6.17 The risks associated with the disposal of VLLW from the non-nuclear industry (excluding the oil and gas sectors) have been reviewed by SNIFFER [Ref. 16] As a consequence of this review, SNIFFER has concluded that "current practices of management and disposal of VLLW from the non-nuclear sector remain acceptable, and that the increasing occurrence of waste segregation and recycling does not appear to be significant in terms of radiological safety...".

Environmental monitoring around landfills taking solid radioactive waste

A6.18 Regular UK-wide monitoring of food and the environment for radioactivity is conducted by the Food Standards Agency and the environmental regulators, and the results reported annually in the “RIFE” reports (Radioactivity in Food and the Environment). The bulk of the monitoring is related to discharges from the nuclear industry, including the environment around the LLWR near Drigg. Leachate and water from boreholes are also monitored at a number of landfill sites known to have accepted (or still be accepting) solid radioactive waste, both as controlled burials and as VLLW as part of Directive waste. The sites are named and displayed on a map of the UK in the RIFE report and data are presented (Bq per litre) for a range of artificial and natural radionuclides. Most results are beneath limits of detection, and in 2007, the programme of monitoring landfill sites in England and Wales was reduced significantly because data from the previous, larger programme, collected over many years, showed that any enhancements in concentrations were predictable and gave rise to doses of very low significance However, low levels of caesium-137 are found in some leachate and there is evidence for the migration of tritium at some sites. This is considered a “worst case” scenario and assumes an inadvertent consumption of 2.5 litres of leachate containing the highest concentration of tritium would result in a dose of less than 5 microsieverts. Leachate is extremely unlikely to be drunk directly – it is discharged to streams and very quickly becomes highly diluted. Therefore consumption of drinking water which might have had some leachate discharged into original water sources is likely to result in extremely small doses. The RIFE reports also contain data on radioactivity levels in freshwater before its treatment and supply to the public water system. Levels of tritium and other radionuclides are well below EU and WHO screening values.

Table 6.2: Summary of assessed radiation doses from management of LLW and VLLW from the non-nuclear industry

Type of disposal or practice	Assessed doses - microsieverts (μSv) per year
Handling of VLLW by workers	Doses to workers from handling wastes and working in close proximity to bulk wastes: maximum doses of just under 20SμSv/year from certain items of waste; around 0.2μSv/year from routine handling of waste items; around 0.08μSv/year from handling of bulk wastes [Ref. 16]
VLLW (primary) to landfill	Maximum dose to public: around 1μSv/year [Ref 16]
VLLW for incineration (at non licensed[9] incinerator)	Maximum dose to public: in case of a medium sized incinerator, around 0.001μSv/year; and for a large incinerator to be significantly less than 20μSv/year [Ref. 16]
LLW to controlled burial	Maximum doses to workers and the public of 10 μSv/year, based on the concept of radiological capacity, and subsequent authorisation conditions.
LLW for incineration[10] (at licensed incinerator)	Doses to public from exposure to discharges from incineration (gaseous and aqueous) are less than 10μSv/ year.
VLLW management from operation of licensed incinerators – creating 'secondary VLLW'	The SNIFFER 2007 report [Ref. 16] states that a single landfill could take approximately 3000 tonnes of secondary VLLW at the limit of activity for low volume VLLW (i.e. 400 kBq per 0.1 m^3) without calculated doses exceeding 20 μSv/year.
VLLW and LLW disposal from oil and gas sectors	Apart from the LLWR near Drigg in Cumbria, no landfill sites currently take VLLW or LLW NORM from the oil and gas industries[11]. Dose assessments from landfill disposals would need to be done on a site-specific basis. However, permits to dispose of the waste to landfill would only be permitted if the

[9] "Licensed" in this table means under radioactive waste regulations.

[10] The Environment Agency is currently reviewing all aspects of dose assessment associated with the incineration of radioactive waste.

[11] NORM that is exempt from radioactive waste regulations may be landfilled without an associated environmental permit.

Type of disposal or practice	Assessed doses - microsieverts (µSv) per year
	levels of predicted dose to members of the public met the regulators' dose constraint for this disposal route[12].

[12] The Environment Agency will not permit disposals to landfills unless they are satisfied that any exposures will be beneath a dose constraint of 300 µSv per year. In most cases, they expect them to be no greater than 10 µSv per year.

Annex 7: Risks from radiation

Health effects arising from a radiation dose

A7.1 The main impact that a low level exposure to ionising radiation has on the health of an exposed person is the possibility of a small increase in the chance of that person developing cancer at some time, usually many years, in the future. The higher the level of dose that is received, the higher the level of increased risk of developing cancer. There is no direct evidence that very low levels of radiation cause cancer but evidence is available from higher levels of exposure.

A7.2 This increased chance of developing cancer occurs because, when ionising radiation passes through living tissues, some of the energy carried by the radiation is lost to the tissue's cells and this energy may cause damage to the genetic material (DNA) within those cells. Cells have very effective mechanisms for the repair of DNA damage resulting from radiation exposure and other causes but some damage is more difficult to repair and sometimes mistakes occur, called mutations. Some mutations can result in changes in the characteristics of cells and set them on a path towards proliferation of cancer.

A7.3 As well as the possibility of causing cancer in the exposed individual, it is biologically feasible that mutations to genetic material could be passed on to future generations (this is called a hereditary effect). However, there is no direct evidence of radiation-induced hereditary effects in humans and this genetic risk is judged to be much lower than that of cancer.

Estimating risks from radiation doses

A7.4 Radiation risk factors are used to relate the exposure to radiation (measured in Sv, see Annex 7 for explanatory information) to the additional risk of developing cancer and to the additional risk of dying from that cancer. An estimation of the level of risk per unit of dose received has been made by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). This estimation is largely based on epidemiological studies of populations such as patients given medical exposures and workers receiving occupational exposures.

A7.5 At very low levels of dose the assumed increase in the risk of cancer is very small and impossible to detect in epidemiological studies, so it is not possible to determine whether there is a dose level below which no effects occur at all. However, current knowledge of biological mechanisms does not support a low dose threshold below which cancer risk can be discounted. Accordingly, to protect people as much as possible, it is commonly assumed that any level of exposure, however small, may cause harm, and that the relationship between risk and dose is linear, with the increased risk being proportional to the dose received. The International Commission on Radiological Protection (ICRP) made adjustments to the risk factor for high dose and high dose rates to allow for the lower doses and lower dose rates typical of occupational or environmental exposures, and this led to their 2007 recommendation [Ref 20] that a fatal cancer risk from ionising radiation of 5% per Sv continued to be appropriate for radiation protection.

Confidence in the value of the radiation risk factor

A7.6 It is recognised that there are some unavoidable uncertainties in the calculation of the radiation risk factor, and that there are alternative views to those held by UNSCEAR and ICRP. However, based on the body of evidence that has been collected over a large number of years, including detailed, regular and recent reviews of biological and epidemiological data, the Health Protection Agency (HPA) has confidence that the radiation risk factors recommended by ICRP provide a sound basis for the protection system and standards which are applied in the UK and internationally.

Levels of risk arising from disposal of non-nuclear industry radioactive waste

A7.7 The doses from non-nuclear industry radioactive waste are presented in Table 6.2, and the highest level of dose given is 20 μSv (20 millionths of a sievert) per year to workers handling certain items of VLLW wastes, and working in close proximity to bulk wastes. An estimate of the associated risk can be obtained by applying the ICRP risk factor of 5% per Sv, giving a risk of 10-6 or one in a million (0.0001%) of contracting cancer as a result of such exposure.

A7.8 The current average risk of dying from cancer in the UK is one in four (25%) [Ref. 23]. Therefore the total risk of dying of cancer rises to around 25.0001% for each worker handling the waste who is exposed to 20μSv annual radiation dose. Expressed differently, this estimate of risk indicates that if 1 million workers handled this waste and each received this dose, then only one worker would be expected to die of a corresponding radiation induced cancer, while about 250,000 naturally occurring cancer deaths would be expected. Such an increase is not detectable because of the normal variations in cancer incidence within populations.

Comparison with other risks

A7.9 When considering a risk in terms of a numerical value, it is important to be aware of what the term risk actually means. A numerical risk is a likelihood that something undesirable might happen as a result of a particular hazard. In this case radioactive waste is the hazard which leads to a risk that the people who receive a radiation dose from the management of the radioactive waste may develop or die from cancer.

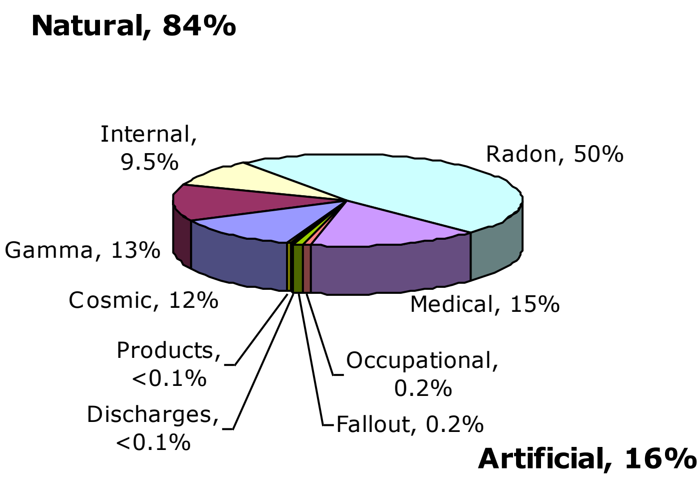
A7.10 It is also important to compare the level of risk with other risks, to help give an idea of exactly how dangerous the hazard is. As indicated above, the risk of dying of cancer as a result of the highest estimated radiation dose arising from management of waste from the non-nuclear industry is estimated to be around one in a million (0.0001%). The Health and Safety Executive (HSE) have looked at levels of risk, and in particular have assessed tolerability and acceptability of different levels of risk. They found that an additional level of risk of one in a million per year to a person is generally considered to be ‘acceptable’, where an ‘acceptable’ risk is one ‘that for purposes of life or work, we are prepared to take pretty well as it is’ [Ref.24].

A7.11 With the average annual dose of 1.6 mSv from occupational exposure to radiation [Ref. 24] equating to a risk of 80 per million, it can be seen that the estimated one in a million maximum risk from management of waste from the non-nuclear industry is 80 times lower than the average occupational risk due to ionising radiation. The one in a million can also be compared to the 0.1% (1 in a thousand) risk associated with the 20 mSv (20 thousandths of a Sievert) annual dose limit for employees working with radiation [Ref. 18]. The estimated risk to workers involved in the management of waste from the non-nuclear industry is one thousand times lower than this limit. Even when compared with the lower risk associated with the maximum dose allowed for a member of the public in the UK (1 mSv per year) [Ref. 25], the maximum risk level associated with waste disposal from the non-nuclear industry is a factor of 50 lower than this public limit.

A7.12 Other levels of risk that are often found helpful for comparison purposes are the projected annual risk from the average natural radiation dose in the UK (100 in a million) –and the annual risk of death from lightning (1 in 18.7 million) [Ref. 26].

A7.13 The doses and risks from non-nuclear industry radioactive wastes can also be put into context by considering the average annual dose of radiation received by people in the UK. The average annual dose of 2.7 mSv is made up of naturally occurring and artificial radiation sources, as shown in Figure 2. Thus the 20 μSv per year discussed above equates to 0.75% of the average annual dose of 2.6 mSv.

Figure 7.1 - breakdown of the average annual dose of ionising radiation received in the UK



Protection of the environment and habitats

A7.14 Until recently, radiation protection philosophy has been based on the premise that if humans are adequately protected, then the natural environment will also be protected. However, the Water Framework Directive and the Habitats Directive have been the driving force behind recent work by the Environment Agency and SEPA to consider the potential effects of anthropogenic radioactivity (i.e. radioactivity derived from human activities) on wildlife. The agencies have concluded there was little risk to wildlife inhabiting Natura 2000 sites from the permitted discharges of radioactive substances from nuclear and non-nuclear sites to the environment [Ref. 27]. Further work by the Environment Agency has considered risk to Natura 2000 sites from radioactive discharges within England and Wales [Ref. 28]. Screening assessments have been made to identify those Natura 2000 sites which may be affected by permitted releases of pollutants and thus require a more detailed assessment. These assessments have now been undertaken for all Natura 2000 sites in England and Wales. Only one site in England and Wales (the Ribble and Alt Estuary Natura 2000 site) has required further attention. In this case, radionuclides released from a nuclear licensed site were identified as the dominant source of exposure but from January 2008 their permitted releases were reduced due to changes in operational practice on site. A reassessment of the Natura 2000 site was undertaken at these new discharge limits and has shown the potential impact is now at a level that the Environment Agency can be confident will have no adverse impact on the Natura 2000 site.

Sustainability Appraisal

A7.15 Early on in its work, the programme board considered the need to undertake a Strategic Environmental Assessment (SEA). On the grounds of very low risks to health from non-nuclear industry disposals, but more particularly because the board would produce a high level strategy and not one based on specific disposal sites, advice from SEA experts was that the requirements for SEA would not apply. However, the process of undertaking some aspects of a sustainability appraisal (SA) of the strategy was thought to be of value. For this reason, a scoping report on SA for the strategy [Ref. 17, 17a] was developed and consulted on from 9 January - 13 February 2009. This report included:

- The identification of other plans and programmes of relevance to the strategy;
- The development of sustainability themes and their relationship to draft SA objectives;
- Baseline information and associated UK maps on:
  - Current and predicted Directive waste arisings and disposal capacity by region;
  - A spatial analysis of data from the Atkins project in terms of waste planning authorities;
  - A summary of health and environmental impacts of LLW waste transport and disposal;
  - An analysis of disposal facilities currently available to take LLW, mostly identified from the Atkins project;
  - Identification of key sustainability issues and implications and opportunities for the strategy;
  - Development of draft objectives and indicators.

A7.16 Thirteen responses were received to the scoping report consultation. These were analysed and are reported on separately.

A7.17 As it had been determined that SEA/SA were not requirements for the non-nuclear industry waste strategy, further work on the SA in line with statutory procedures was not thought to be justified. Nonetheless, the process has been useful in considering the strategy, and key SA issues identified in the scoping report have been cross-referenced to items in the strategy in Annex 8. The indicators developed under the SA objectives will also be valuable for any future review of the strategy.

Annex 8: Cross referencing of key issues and implications and opportunities for the strategy, identified in the scoping report on sustainability to the non-nuclear waste strategy

Key issue from table 4.1 in SA Scoping report	Implications and opportunities for strategy from table 4.1	Relevant aspects of the strategy
1. Changes in activities, amounts and sectoral distribution of non-nuclear LLW/VLLW	Strategy should: a) encourage waste generators to minimise LLW and VLLW arisings; b) help identify disposal routes for future arisings	(a) 2.49 – 2.55 (b) 2.36
2. Lack of information on LLW and VLLW arisings	Strategy should: involve and be informed by data collection on waste arisings.	Annex 3
3. Limited capacity and uncertain future of LLWR near Drigg	Strategy should: encourage waste generators to minimise LLW arisings and seek disposal routes other than the LLW near Drigg to relieve pressure on it.	2.49 – 2.55
4. Limited opportunities for LLW and VLLW landfilling	Strategy should: a) identify UK requirement for non-nuclear industry LLW disposal and key areas where there are constraints; b) help ensure fuller integration of LLW disposal considerations in WPAs plans; c) help reverse the decline in landfills accepting LLW.	(a) Annex 3 (b) 2.33)c) 2.35 – 2.36
5. Barriers to LLW and VLLW incineration	Strategy should: promote use of incineration as one of the means of managing radioactive waste, especially for waste not suitable for disposal to landfill.	2.50

Key issue from table 4.1 in SA Scoping report	Implications and opportunities for strategy from table 4.1	Relevant aspects of the strategy
6. Lack of certainty regarding options NORM waste disposal	Strategy should: a) help facilitate the identification of feasible disposal options for NORM; b) help increase access to landfill sites for NORM.	N/A – separate strategy
7. Disincentives to dispose of LLW locally, resulting in increasing transportation	Strategy should: a) encourage engagement and consultation with the public; b) help promote proximity principle for non-nuclear industry LLLW; c) identify UK requirement for non-nuclear industry waste disposal and key areas where there are constraints; d) help ensure fuller integration of LLW considerations in WPA plans; e) help identify cost-effective options for non-nuclear industry waste disposals.	(a)2.37 (b) 2.29 – 2.30 (c) Annex 3 (d) 2.33 (e) 2.28
8. Climate change consequences	Strategy should: inform stakeholders on need to consider coastal erosion and climate change issues etc when developing recommendations for disposal routes.	N/A
9. Cumulative effects from radionuclide accumulation	Strategy should: Confirm radiological effects from solid LLW and VLLW disposals remain low.	2.9, 2.20

Annex 9: Membership and terms of reference of the Non-Nuclear Industry Waste Strategy Programme Board

Chairmen: Robert Jackson (Defra) from June 2007 to April 2008; Steve Chandler (Defra/DECC) from April 2008.

Technical Secretariat: Katherine Mondon (up to December 2009), Hannah Manson (up to January 2011) and Allan Ashworth (from February 2011).

Defra/DECC Secretariat: Sophie Shepherd (up to April 2008), Stephen Allen.

Members	
Arkins, Gerry	Department of the Environment, Northern Ireland
Borwell, Mick	Oil and Gas UK
Cairns, Bruce	Department of Energy and Climate Change
Chandler, Steve	(Chairman) Department of Energy and Climate Change
Fisher, Joanne	Nuclear Decommissioning Authority
Goan, Kate	Scottish Non-Nuclear Industry Liaison Group
Greedy, Derek	West Midlands Regional Technical Advisory Body
Linksey, Diana	Department for Environment, Food and Rural Affairs
Marsden, Peter	Small Users Liaison Group
McNulty, Greg	Huntsman (NORM Industries)
Murfin, Rob	English Regional Technical Advisory Bodies

Members	
Plummer, Mark	Department for Communities and Local Government
Regnier, Tony	Department of Energy and Climate Change
Russ, Bob	Environment Agency
Stackhouse, Adam	Scottish Environment Protection Agency
Williams, Robert	Welsh Assembly Government
Young, Ewan	Scottish Government

Terms of reference

A9.1 The principal objective of the Board was to develop and recommend to Government a Non-Nuclear Industry Waste Strategy for the whole of the UK. The work of the Board covered one-off targeted data collection across the UK from the non-nuclear industry, with the subsequent development of an initial non-nuclear industry waste strategy. The board was also asked to recommend work to improve routine data inputs to the regulators from the non-nuclear industry. Further updates to the strategy that might be required from time-to-time, were outside the scope of the work of the board.

A9.2 During its work, the Board would liaise with organisations that were likely to be most affected by the strategy – that is the non-nuclear industry, waste disposal facility operators, the Nuclear Decommissioning Authority and planning authorities. These bodies would be included in a consultation on a scoping report for sustainability appraisal of the strategy. This intermediate consultation would be followed by a public consultation on the strategy.

Success criteria

A9.3 Success criteria and how they would be assessed were as follows:

1. Improved understanding of the problems faced by the non-nuclear industry in dealing with their arisings – assessed from contractor's report on collection of data from the non-nuclear industry;
2. Broad support for the strategy during the public consultation;
3. Inclusion of requirements identified in the non-nuclear industry waste strategy within local authority planning frameworks – assessed by feedback from the Department for Communities and Local Government (DCLG) in the case of England, and the devolved administrations in the cases of Wales, Scotland and Northern Ireland;

4. A range of identified disposal facilities across the UK that can (or could, in the case of planned facilities) also take non-nuclear industry wastes e.g. regional incinerators and local landfills – assessed by feedback from users and individual EA and SEPA inspectors that these disposals are adequately catered for;
5. An overall reduction of “waste miles” compared to the current position – assessed by data gathered from the non-nuclear industry;
6. Clarity for the non-nuclear industry, environment agencies and planning authorities as to what facilities are available for what sorts of wastes – assessed in terms of production of guidance.

Glossary

Activity	The number of atoms of a radioactive substance which decay by nuclear disintegration each second. The unit of activity is the Becquerel (Bq) which is equivalent to one disintegration per second.
Air pollution control residues (APCR)	During incineration, the emissions are cleaned using various systems (scrubbers) before being finally discharged to the atmosphere. The cleaning systems result in residues which require disposal (or some may be recycled into other materials). See also ash, lime and sludge.
As Low As Reasonably Achievable (ALARA)	The ALARA principle is contained in the European Basic Safety Standards Directive 96/29, which is transposed into UK law. Essentially, it requires that all reasonable steps should be taken to protect people and the environment. In making this judgement, factors such as the costs involved in taking protection measures are weighed up against benefits obtained, including the reduction in risks to people and the environment.
Alpha radiation	Alpha radiation takes the form of particles (helium nuclei) ejected from some decaying (radioactive) atoms. Alpha particles cause ionisations in biological tissue which may lead to damage. The particles have a very short range in air (typically about 5cm) and if present in materials that are outside the body, they are prevented from causing biological damage by the superficial dead skin cells, but become significant if inhaled or swallowed.
Ash	Two types of ash arise from incineration – bottom ash which remains in the grate after combustion, and smaller particles comprising fly ash which is present in the emissions, and which is removed from the gases prior to their discharge. Ash is sent to landfill although a proportion is reused in construction.
Basic Safety Standards (BSS) Directive 96/29/Euratom	An abbreviation for the European Union “Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation”. In the UK, this directive is implemented by country-specific regulations.

Becquerel (Bq)	The standard international unit of radioactivity equal to one radioactive transformation per second. LLW and VLLW are classified according to their radioactive content per unit mass. Multiples of becquerels commonly used in quantifying radioactive waste are: kilobecquerel (kBq) equal to one thousand Bq and megabecquerel (MBq) equal to one million Bq.
Best Available Technique (BAT)	BAT is defined (using the definition in article 2 of the PPC Directive) as the most effective and advanced stage in the development of activities and their methods of operation, which indicates the practical suitability of particular techniques for providing, in principle, the basis for emission limit values designed to prevent and where that is not practicable, generally to reduce emissions and impact on the environment as a whole. In England and Wales BPEO + BPM = BAT.
Best Practicable Means (BPM)	BPM requires operators to take all reasonably practicable measures in the design and operational management of their facilities to minimise discharges and disposal of radioactive waste, so as to achieve a high standard of protection for the public and the environment. BPM takes account of factors such as the availability and cost of relevant measures, operator safety and the benefits of reduced discharges and disposals. If the operator is using BPM, radiation risks to the public and the environment will be As Low As Reasonably Achievable (ALARA).
Beta radiation	Beta radiation takes the form of particles (electrons) emitted from the nucleus of some decaying (radioactive) atoms. Beta particles cause ionisations in biological tissue which may lead to damage. Most beta particles can pass through the skin and penetrate the body, but a few millimetres of light materials, such as aluminium, will generally shield against them.
Beta/gamma radiation	Beta radiation is usually accompanied by the emission of gamma rays, hence the term “beta/gamma activity”.
Clinical waste	All clinical wastes are hazardous waste, with two exceptions: • Segregated non-hazardous medicines; • Clinical wastes from non-healthcare activities. Wastes are normally clinical waste due to the presence of hazardous chemicals or pharmaceuticals, or because they may cause infection. With the exception of medicines that are

	classified as non-hazardous, clinical waste is therefore normally classified as hazardous waste. Facilities authorised to incinerate or treat clinical wastes are required to assess and have operational access to additional detailed information on the composition of a waste from the producer before they receive it. This information forms part of their 'pre-acceptance' checks. This requirement is designed to ensure that the waste is properly treated without harm to human health or the environment.
Contaminated land	In this report, contaminated land refers to radioactive contaminated land. It is a special case of land that is determined as Contaminated Land under Part 2A of the Environmental Protection Act 1990 as it is causing harm or there is a significant possibility of such harm being caused. Harm is defined as "lasting exposure resulting from the after effects of a radiological emergency, part practice or past work activity".
Controlled burial (also known as special precautions burial in Scotland)	A process for disposal for solid LLW that has an activity level above that which would allow it to be disposed of as VLLW. Controlled burial takes place at landfill sites used for the deposit of substantial quantities of non-radioactive waste but which are approved for the disposal of radioactive substances. Controlled burial has various limitations placed on its use in terms of maximum activity per waste container, type of container, surface dose rate of container, and depth of burial beneath earth or non-radioactive waste.
Directive waste	As defined in Article 3(1) of the Waste Framework Directive (2008/98/EC), waste means any substance or object which the holder discards or intends or is required to discard. This application of the Directive is qualified under Article 2, which provides exclusions from its scope. Radioactive wastes are excluded from the scope of the Directive under Article 2(d).
Decay chains	These generally refer to the three naturally occurring series of radionuclides, all of which start with a single parent (uranium-238, uranium-235 and thorium-232) each of which decays via a number of radioactive daughters of different half-lives, eventually ending with stable nuclides of lead.
Decay Storage	The process of allowing material containing short-lived radionuclides to decay so that the final waste is easier to dispose of as radioactive waste, or until the point where the

	waste becomes exempt from specific regulatory requirements. Used extensively in hospitals and research establishments, and to some extent by the nuclear industry.
Disposal	In the context of solid waste, disposal is the emplacement of waste in a suitable facility without intent to retrieve it at a later date; retrieval may be possible but, if intended, the appropriate term is storage. Disposal may also refer to the release of airborne or liquid wastes to the environment (e.g. emissions and discharges).
Dose constraint	When a practice involving ionising radiation is being planned, a level of dose is often set to restrict future doses that might be received from that practice. This level of dose is called a dose constraint, and will differ depending on the practice being planned. Dose constraints are less than the legal dose limit.
Dose limit	Dose limits are maximum levels of radiation dose per year which are laid down in UK Law. For members of the public, the dose limit is 1 millisievert per year. Dose limits apply to all non-medical practices which involve a risk from ionising radiation coming from an artificial source, or from a natural radiation source in cases where natural radionuclides are, or have been, processed because of their radioactive, fissile or fertile properties. Different dose limits apply to workers.
Environment Agency (EA)	The environmental regulator for England and Wales. The Environment Agency's role is the enforcement of specified laws and regulations aimed at protecting the environment, in the context of sustainable development, predominantly by authorising and controlling radioactive discharges and waste disposal to air, water (surface water, groundwater) and land. In addition to permits under EPR 2010, the EA also regulates nuclear sites under the Pollution Prevention and Control Regulations and issues consents for non-radioactive discharges.
Environmental Permitting Regulations 2010	In England and Wales, these have replaced a suite of current environmental legislation which includes the Radioactive Substances Act 1993.
Exemptions	The radioactive waste regulations make provision for certain low activity wastes, when used for certain purposes and when managed in particular ways, to be exempted from particular

	regulatory provisions made under the regulations.
Gamma radiation	An electromagnetic radiation similar in some respects to visible light but with higher energy. Gamma rays cause ionisations in biological tissue which may lead to damage. Gamma rays are very penetrating and are attenuated only by shields of dense metal or concrete, perhaps some metres thick, depending on their energy. Their emission from a radionuclide during radioactive decay is usually accompanied by particle emissions (beta or alpha particles).
Half life	The time required for one half of the atoms of a given amount of a particular radionuclide to disintegrate through radioactive decay. Each radionuclide has a unique half-life and half-lives vary from fractions of a second through to many millions of years. The half-life of a radionuclide is therefore of fundamental importance when considering its safe long-term management.
Hazardous waste	Hazardous wastes are those wastes that display one or more hazardous properties as set out in Annex 3 of EC Waste Framework Directive. They are harmful to human health, or to the environment, either immediately or over an extended period of time. Hazardous wastes are listed in the List of Wastes (England) Regulations 2005 and marked with an asterisk.
Ionising radiation	When radiation (alpha or beta particles and gamma rays) interacts with matter, it can cause atoms and molecules to become unstable (creating ions). This process is called ionisation and alpha and beta particles and gamma rays are often referred to collectively as ionising radiation. Ionisation within biological tissue is the first stage in radiation leading to possible change or damage within the tissue.
International Commission on Radiological Protection (ICRP)	An advisory body founded in 1928 providing recommendations and guidance on radiation protection. ICRP recommendations normally form the basis for EU and UK radiation protection standards.
Labelling of chemicals (with radioisotopes)	See Radioactively labelled tracers.
Leachate	Liquid that has seeped through a landfill (waste disposal) site, and which contains a variety of soluble constituents of the

	waste.
Lime (in the context of incineration)	Lime is used to neutralise acidic gases present in emissions. Reacted lime is part of an incinerator's air pollution control residues (along with ash and sludges), and is sometimes reused or recycled in the chemicals industry.
Low Level Waste (LLW)	Covers a variety of materials which arise principally as lightly contaminated miscellaneous scrap and redundant equipment from both the nuclear and non-nuclear industries. Organic materials in LLW are mainly in the form of paper towels, clothing and laboratory equipment that have been used in areas where radioactive materials are used – such as hospitals, research establishments and industry. See box 2 for formal definition of LLW. Both waste producers and sites accepting LLW as controlled burials have to have permits under the radioactive waste regulations, although this requirement on waste facility operators has only applied recently, as a consequence of the Government's new policy statement on the management of LLW.
Low Level Waste Repository (LLWR)	A facility taking only LLW. The UK's only LLWR is near Drigg in Cumbria, which has operated as a national LLW disposal facility since 1959. Wastes are compacted and placed in containers before being transferred to the facility. Following a major upgrade of disposal operations completed in 1995, all LLW is now disposed of in engineered concrete vaults. The LLWR near Drigg is owned by the Nuclear Decommissioning Authority and currently managed by UK Nuclear Waste Management Ltd.
Microsievert	One millionth of a sievert (see sievert)
Natura 2000	A Natura 2000 site is a protected ecological area within the European Union containing threatened habitats and/or species. Previously established Special Protection Areas (SPAs) for Birds and Special Areas of Conservation (SACs) for other species make up the Natura 2000 network of protected sites.
Non- nuclear industry	A collective term for a wide range of organisations that handle radioactivity for specific purposes, and/or that create radioactive waste as a result of their operations, as a consequence of which they are required to be registered or authorised under the RSA 93/ EPR 2010. The non-nuclear industry is distinguished from the nuclear industry by the fact that the latter covers industries involved with nuclear energy, the production of

	nuclear weapons and large scale radioisotope production. The nuclear industry is subject to additional regulation.
NORM	Naturally occurring radioactive material arising principally from a\ number of industrial processes, including metals refining and oil and gas extraction.
NORM wastes	Radioactive waste produced by organisations as a by-product of their processing of material containing natural radioactivity.
Nuclear Decommissioning Authority (NDA)	The NDA was set-up on 1 April 2005, under the Energy Act 2004. It is a non-departmental public body with designated responsibility for managing the liabilities at specific sites. These sites are operated under contract by site licensee companies. Its sponsoring Government department is the Department of Energy and Climate Change (DECC) which approves its strategy, plans and budget. The NDA also reports to the Scottish Ministers who agree its strategy and plans for Scottish sites.
Nuclear medicine	The use of radioisotopes and radioactivity in the diagnosis and treatment of diseases.
Radioactive decay	The process by which a radionuclide undergoes transformation with the emission of ionising radiation (see also half life).
Radioactive Substances Act 1993 (RSA 93)	Legislation used in Scotland and Northern Ireland which provides for regulation of the disposal of radioactive wastes, including liquid and gaseous discharges to the environment and provided for the regulation of the accumulation of radioactive wastes on non-nuclear sites (see also Environmental Permitting Regulations 2010).
Radioactively labelled tracers	Chemicals in which some stable atoms are replaced by (i.e. labelled with) radioisotopes. The radioactive decay of the radioisotopes then allows chemical and biological reactions involving the tracer to be followed.
Radioisotope	Different radioactive forms of the same element, for example phosphorous-32 and phosphorous-33 are both radioisotopes of the element phosphorous.

Radionuclide	A generic term which refers to any radioisotope of any element, so for example, tritium (H-3), carbon-14 and caesium-137 are all described as radionuclides.
Radiopharmaceutical	A general term for radioactively labelled tracers used in the diagnosis or treatment of disease.
Scottish Non-Nuclear Industries' Liaison Group (SNNILG)	Run by SEPA for Scottish non-nuclear industries, it has similar objectives to its English equivalent, SULG (see Small Users' Liaison Group).
Scottish Environmental Protection Agency (SEPA)	The environmental regulator for Scotland, SEPA's role is the enforcement of specified laws and regulations aimed at protecting the environment, in the context of sustainable development, predominantly by authorising and controlling radioactive discharges and waste disposal to air, water (surface water, groundwater) and land. In addition to authorisations issues under the RSA 93, SEPA also regulates nuclear sites under the Pollution Prevention and Control Regulations and issues consents for non-radioactive discharges.
Sievert (Sv)	A unit of radiation dose to living tissue, equal to 1 joule per kilogram (which is a measure of energy taken up as radiation passes through matter). It is a very large unit, and sub multiples of the Sv are more commonly used, for example: • the microsievert is one millionth of a Sv, or • the millisievert is one thousandth of a Sv.
Sludge (in the context of incineration)	Incinerator gases are usually passed through sprays (wet scrubbers) as part of the air pollution control systems. Very small sized particles are removed by this process and are then passed as suspensions through waste treatment plant which concentrate these particulates into sludges. Sludges are therefore part of the incinerator's air pollution control residues, along with ash and residues from gas neutralisation (see lime).
Small Users' Liaison Group (SULG)	An Environment-Agency run group of non-nuclear industry representatives that meets approximately twice a year. HSE and DECC are also on the membership. SULG's objectives are to provide: a forum for effective liaison, communication and consultation between non-nuclear users of radioactive substances and the EA; an improved understanding of EA and Users' objectives, priorities and constraints in respect of the management of radioactive waste, with the aim of improving

	both the clarity and consistency of regulation.
Strategic Environmental Assessment (SEA)	In this document, SEA refers to the type of environmental assessment legally required by EC Directive 2001/42/EC in the preparation of certain plans and programmes. The authority responsible for the plan or programme must prepare an environmental report on its likely significant effects, consult the public on the report and the plan or programme proposals, take the findings into account, and provide information on the plan or programme as finally adopted.
SNIFFER	Scotland and Northern Ireland Forum for Environmental Research. A limited company and registered charity which organises and publishes research on behalf of its members. Recent publications relating to radioactive waste have covered arisings from the oil and gas industries (UKRSR07), controlled burial of LLW at landfills (UKRSR03), and a review of the management of VLLW (UKRSR09) See www.sniffer.org.uk
Sustainability Appraisal (SA)	A form of assessment used in England covering the social, environmental and economic effects of proposed plans and appraising them in relation to the aims of sustainable development. SAs fully incorporating the requirements of the SEA Directive (2001/42/EC) are mandatory for a range of regional and local planning documents under the Planning and Compulsory Purchase Act 2004.
Tritiated water	Tritium (H-3) is the radioisotope of the element hydrogen. It can replace hydrogen atoms in molecules, which then become “tritiated”. If the molecule is water, this is then called tritiated water.
UNSCEAR	The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) is an expert body that assesses the consequences to human health of a wide range of doses to ionising radiation and estimates the dose to people all over the world from natural and man-made radiation sources. It presents its reports and scientific annexes to the General Assembly of the United Nations.
Very Low Level Waste (VLLW)	Covers miscellaneous waste arising from both the nuclear and non-nuclear industries with very low concentrations of radioactivity. VLLW is divided into two types: low volume VLLW

	and high volume VLLW . Depending on its physical form, low volume VLLW is incinerated or disposed of to landfill, and neither type of facility has to hold an environmental permit. However, high volume VLLW will need to go to landfills that do hold environmental permits under EPR 2010/ RSA 93.

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