Issues and Challenges for the Disposal of Solid Radioactive Waste in the UK - 16597

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ABSTRACT

The latest UK radioactive waste inventory describes the UK as having roughly 4.5 million m^3 of solid radioactive waste – waste that either exists now or which will arise in future. This quantity excludes the potential waste that could be generated from the final site clearance of nuclear sites, estimated to be at least 3 times the current inventory volume. Most solid radioactive waste (by volume) is managed in the near-surface, at the national Low Level Waste Repository (LLWR) or in other appropriately permitted landfill sites. The UK has yet to develop solutions for the final disposal of Higher Activity Radioactive Waste (HAW) but has established arrangements for packaging of waste now for storage while maximising the probability that these packages will be disposable once a solution is provided. Irrespective of the final disposal solution, the principles that govern the safe management of solid radioactive waste are common across the UK. Recent experience in the UK, including from the review of the environmental safety case for the LLWR, identified a number of issues relevant to solid waste disposal which are pertinent to other existing Low Activity Radioactive Waste (LAW) disposal sites as well as the development of safety cases for HAW disposal facilities. These issues include: scoping the extent of 'wastes' included in any assessment (e.g. whether to include the 'package' as well as its contents); the importance of understanding the waste heterogeneity; non-radioactive characteristics of waste, and understanding of external factors such as climate and landscape change.

INTRODUCTION

Solid radioactive wastes are produced as a result of both nuclear and non-nuclear activities taking place across the UK [1]. About 91% by volume of all radioactive wastes in the UK are produced in England, 6% in Scotland and 3% in Wales. Northern Ireland has no major solid radioactive waste producers, only generating small volumes associated with non-nuclear applications of radioactive substances (e.g. hospitals, and industrial, educational and research establishments).

The majority of solid wastes, by volume, are disposed at near-surface facilities which include the national Low Level Waste Repository (LLWR) in Cumbria, north-west England, the Dounreay LLW Facility (on the north coast of Scotland) and at three commercial landfills which each have specific permits for the disposal of radioactive wastes. The disposal of wastes in these near-surface facilities is permitted on the basis of the demonstration of a suitable environmental safety case in accordance with the requirements for acceptance described within guidance published jointly by the environment agencies across the UK [2].

The UK has yet to develop solutions for the final disposal of Higher Activity Radioactive Waste but has established arrangements for packaging of waste now for storage while maximising the probability that these packages will be disposable once a solution is provided. Guidance, similar to that produced for permissioning of a near-surface disposal facility, has been produced by the Environment Agency and the Northern Ireland Environment Agency to address the permissioning of a geological disposal facility for radioactive wastes [3]. Scottish Government policy for higher-activity solid radioactive wastes does not support geological disposal and so this guidance is not sponsored by SEPA.

In line with the requirements of relevant EC Directives, international standards and good practice, a future geological disposal facility will be licensed and regulated for nuclear safety purposes by the Office for Nuclear Regulation during its design, construction and operation, up until the conclusion of disposal operations sealing of the facility. Licensing a geological disposal facility will not impact on the environment agencies' requirements or permitting process. Permissioning of disposal itself and regulation following the completion of disposal activities is the responsibility of the environmental regulator.

GUIDANCE ON REQUIREMENTS FOR AUTHORISATION FOR DISPOSAL

The guidance for both near-surface disposal and geological disposal is aimed principally at the developers of any such facilities. It explains the requirements that the regulators expect a developer to fulfil when applying for a permit to develop and then operate such a facility. The guidance sets out the UK radiological protection requirements and explains the regulatory process that leads to a decision on whether to authorise the radioactive waste disposal facility. It also describes the environmental safety case that the regulators would expect to be submitted by the developer of a disposal facility.

The developers of facilities for solid radioactive waste disposal have to demonstrate that their facilities will properly protect people and the environment. To achieve this they have to show that their approach to developing their facility; including its location, design, construction, operation and closure are consistent with a series of principles and requirements. The guidance sets out these principles and requirements; each of them start with a short high level summary description followed by more detailed information. One of the most important requirements is

the Environmental Safety Case (ESC); this is the means by which the developer demonstrates how a proposed facility meets all of the other requirements set out in the guidance, and hence that people and the environment are protected from the hazards posed by the waste to be disposed of.

The guidance focuses on five principles for solid radioactive waste disposal and fourteen more specific requirements which, if fulfilled proportionately to the hazard presented by the waste, should ensure that the principles are properly applied.

The principles and requirements, and the relationship between them, are shown in Figure 1.

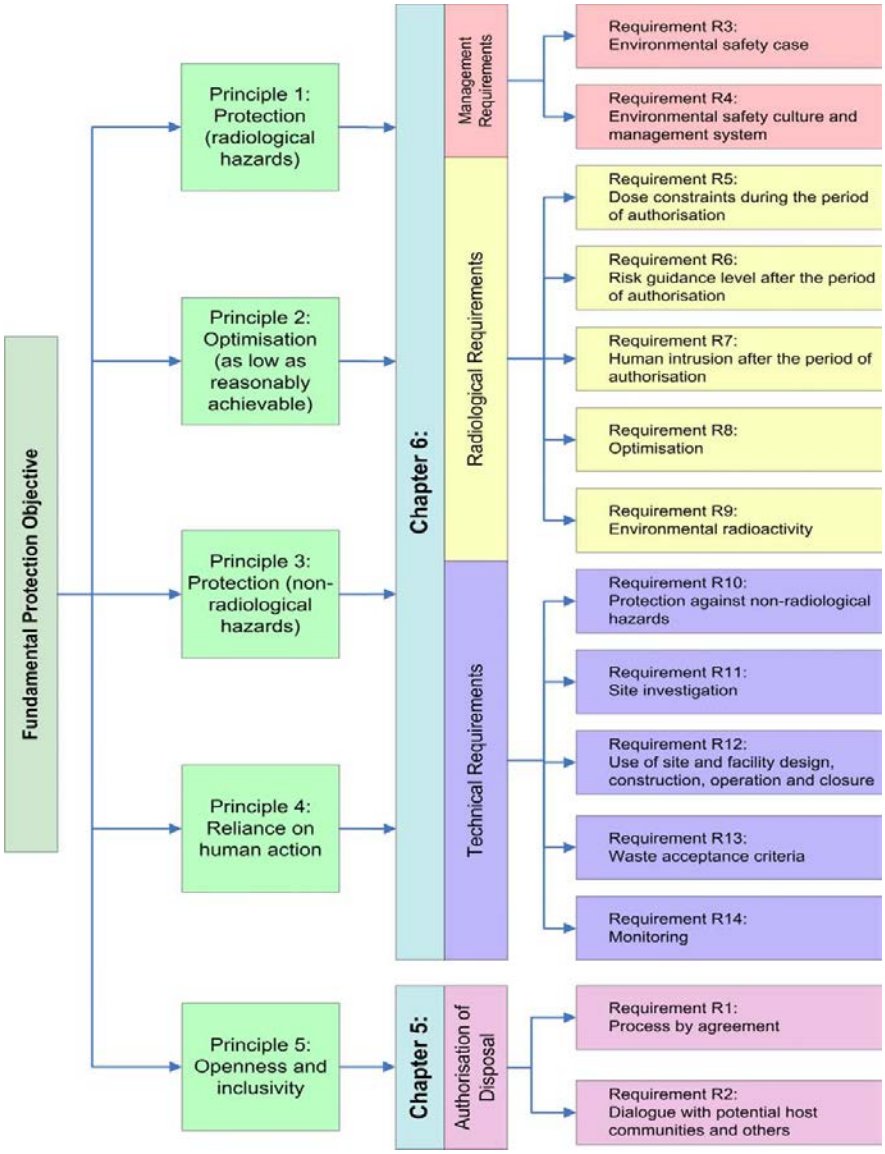

Fig. 1. Relationship between principles and requirements

Application of the guidance

Since the near-surface guidance was produced in 2009 it has been applied in a number of situations across the UK in supporting the development of solid radioactive waste disposal facilities. It has provided the basis for the permitting of three commercial landfills to receive radioactive wastes for disposal as well as the Dounreay LLW facility. These are: Clifton Marsh landfill near Preston in Lancashire, the Lillyhall landfill in Cumbria, and the East Northants Resource Management Facility in Northamptonshire. Most recently it has provided the basis for the Environment Agency's review of the ESC for disposal at the national LLWR in Cumbria.

ISSUES AND CHALLENGES FOR RADIOACTIVE WASTE DISPOSAL

A range of lessons have been learnt from the application of the guidance in these various situations. These are currently being collated and will inform a review and update to the UK guidance in the near future.

The guidance's risk based approach has been successful in enabling the UK solid radioactive waste near-surface disposal infrastructure to be expanded and to enable the diversion of significant quantities of very low level radioactive waste (LLW) away from the LLWR. In 2009 over 95% (by volume) of LLW produced from nuclear sites across the UK was disposed to the LLWR which was quickly reaching capacity. Since then, the permitting of alternative disposal facilities, especially the commercial landfill sites, means that today over 85% (by volume) of LLW generated is diverted away from the LLWR; preserving its vital capacity for those radioactive wastes which require the level of engineering protection it offers. Not only has this diversion enabled the continued operation of the LLWR and delivery of nuclear decommissioning and clean-up across the UK, but it has also enabled significant cost savings as a result of the lower cost of landfill disposal by comparison with costs for LLWR disposal. From 2009 to 2015 over £137 million has been saved by opening alternative routes for LLW disposal in the UK the major of which was achieved through this diversion.

Application of the guidance to the Low Level Waste Repository (LLWR)

The guidance has shown itself to be applicable for a range of developers and operators in a variety of situations due to its risk based approach and encouragement of proportionality. Its most extensive application has been at the LLWR where liaison and engagement on its development started in 2007 leading to a revised submission being made to the Environment Agency in May 2011. The review carried out by the Environment Agency of the LLWR operator's ESC, including the identification and resolution of a range of issues (72 in total), lasted until October 2013. The following summarises a number of the issues for the ESC:

Coastal Erosion

The site is located close to an eroding coastline which will mean that eventually waste will be exposed at the surface. This exposure pathway therefore needed to be considered as one of the main routes for potential exposure of the public and the environment. The assessment needed to demonstrate that at the estimated time for the exposure of the waste the risk to the public and environment would be acceptable. This required: careful consideration of the range of climate change and sea level rise predictions; modelling a range of different types of erosion mechanisms, and understanding the behaviour of the repository wastes once exposed. A conceptual site model to investigate disruption of the facility was constructed and formed the basis for the subsequent development of various exposure scenarios and risk assessments.

The coastal erosion modelling included in the ESC led to the operator recognising the need for specific controls. These included: additional controls on the types of waste accepted for disposal; the overall capacity of disposal at the site, and the strategy for waste emplacement.

Heterogeneity

Previous assessments of the ESC had been based on an assumed homogeneous distribution of activity across individual consignments. This safety case recognised that while the volume averaged properties of any individual consignment met the waste acceptance criteria, the range of materials and activity concentrations within individual consignments was not being considered. The waste disposed to the facility could contain a range of physically distinct items such as sealed sources, metal bars, particles. Similarly the level of activity associated with any such items might vary considerably.

Understanding the heterogeneity of the waste was recognised as an important part of the environmental safety case. The heterogeneity informs the likelihood and subsequent dose implication of encountering the waste following coastal erosion as well as some human intrusion scenarios. Highly active particles presented considerable difficulties in calculating the risk that might be associated with such items due to the very low probability of encounter but the associated potential for significant doses. Discrete items on the other hand presented other difficulties in assessing the likelihood of encounter. These items such as, sealed sources, might be recognisable so provide a potential focus of interest to a future individual as well as potentially contribute a significant dose to that individual.

On the basis of these assessments controls have now been established, as part of the Waste Acceptance Criteria to specifically address particles and discrete items present in waste consignments. There is now a requirement to provide a description of the heterogeneity of the waste within any particular consignment.

Non-radiological impacts

Previous guidance on radioactive waste disposal focused on the radiological characteristics of the waste. The revised guidance, published in 2009 [2], made clear that the non-radiological characteristics of the waste should also be considered as part of the safety case. The aim should be to demonstrate protection of people and the environment to standards no less stringent than those that would otherwise be required by non-radioactive legislation. For the first time this then included the impact of the containers and grout on the repository performance. Particular challenges arose in the consideration of performance standards for non-radiological hazardous components such as asbestos and lead, as well as considering the implication that some of the non-radiological components might have upon the behaviour of the radionuclides (eg tributylphosphate (TBP)).

The assessment also reconsidered the acceptability of complexing agents within the wastes accepted for disposal. Such agents are used extensively across the nuclear industry during decommissioning and clean-up of facilities. Previously any wastes contaminated these chemicals were not allowed to be disposed at the LLWR. The review of the environmental safety case sought to make the case for acceptance of some complexing agents following the extensive testing and assessment of them. It demonstrated that many complexants could be accepted, albeit not in bulk, but that aminopolycarboxylic acids should be limited (eg EDTA, NTA).

As a result of this consideration the permit now includes limits on the inclusion of certain materials (eg mercury) and a requirement within the Waste Acceptance Criteria for greater information from consignors on the non-radiological characteristics of their waste.

Application of the guidance to geological disposal

The UK currently has no geological disposal facility, however, the geological disposal guidance provides the basis for the planning. The Environment Agency, working together with the Office for Nuclear Regulation, has used the guidance to inform Radioactive Waste Management Ltd (RWM), the identified developer of any geological disposal, of the requirements that will need to be met by any environmental safety case in order to authorise a geological disposal facility.

A joint scrutiny programme with both regulators has been established to ensure that RWM's scientific and technical programme provides a sound basis for implementing geological disposal. It is also intended to help ensure that RWM develops into an organisation capable of applying for the environmental permits and nuclear site licence that it will need in the future to operate a geological disposal facility. As part of this work the Environment Agency and Office for Nuclear Regulation have undertaken a regulatory review of RWM's generic Disposal System Safety Case (gDSSC), published in 2011 [4].

The DSSC is termed generic because no site has been selected for geological disposal at this stage so the safety case does not focus on any particular geological environment. Instead the gDSSC includes generic environmental, operational and transport safety cases for a hypothetical geological disposal facility that could be implemented at a range of geologies in the UK.

Whilst RWM is not seeking a permit or licence at this stage the regulators review of the gDSSC was undertaken to provide advice and comment. Indeed the regulatory guidance on requirements for authorisation does not require a generic ESC. However, the review was felt to be important because it provided the regulators with:

1. a basis for early dialogue with RWM on regulatory requirements and also a means of identifying potential future regulatory issues that may need to be followed up;
2. an insight into how RWM might develop a DSSC for any future geological disposal facility together with an improved understanding of the environmental, nuclear and transport safety arguments that RWM might present in a such a safety case;
3. assurance that the gDSSC provides suitable support for RWM's disposability assessments for packaging radioactive waste. RWM currently undertakes disposability assessments to determine whether waste producers' proposals for conditioning and packaging radioactive waste are consistent with the likely requirements for geological disposal. The process has historically been applied to existing intermediate level wastes but it is being expanded to include high level wastes and also possible future radioactive waste from any new nuclear reactors including spent nuclear fuel that might be disposed of as waste;
4. an opportunity to apply and rehearse the approach to regulatory assessment of a DSSC for any future geological disposal facility. The lessons learnt from this help ensure the regulators' approach is effective and that the future regulatory resource requirements are understood;
5. an opportunity to develop the approach to presenting and communicating the findings from the review to RWM and more widely, for example, to communities, local authorities, Government and the public. The regulators are committed to making the findings publicly available and to present the findings in a way that is understandable and accessible to non-technical audiences.
6. an opportunity to identify whether further research will be required to underpin the arguments made in the DSSC.

The combined views of the regulators on the gDSSC were published and confirmed that the gDSSC provided confidence, to a degree appropriate at this early stage in implementing geological disposal, and that a safety case for a geological disposal facility in the UK could be made, providing a suitable site is available. From the review there were no specific issues identified that would prevent a safety case

being made. It did allow the regulators to identify a number of reservations which informed recommendations to RWM to help future development of the gDSSC and progress towards producing an acceptable site-specific ESC for a geological disposal facility.

FUTURE DEVELOPMENTS

The regulators are currently collating the experience from the application of our guidance on requirements for authorisation for disposal, both to the near-surface and geological disposal, from the range of applications that have made use of it. This will inform a review and update to the guidance, currently anticipated to commence by the end of 2016. Work is also underway to develop the principles from our guidance to address in-situ disposal at nuclear sites [5].

CONCLUSIONS

Application of the regulators' guidance across a range of near-surface sites in the UK has resulted in the development of some very different and distinct ESCs. This of course reflects the very site specific nature of the issues that need to be considered in demonstrating the safety of near-surface radioactive waste disposal. It has also provided a useful basis to inform planning for geological disposal.

The issues that have arisen, some of which have been shown to be very site specific in nature (such as coastal erosion), and others more generic (such as the need to consider waste heterogeneity), have highlighted the need for some improvements to our guidance as well as the challenge of presenting some highly technical and complex issues in ways that are understandable and accessible to non-technical audiences.

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