

## **PLANNING THE ACCELERATED RESTORATION OF CONTAMINATED LAND AT THE DOUNREAY EXPERIMENTAL NUCLEAR ESTABLISHMENT, UK**

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### **ABSTRACT**

UKAEA Dounreay started construction in 1955 and operated as a fast reactor experimental facility with associated fuel reprocessing until 1998. The site is now in the early stages of decommissioning. The original decommissioning plan extended to a 100-year period followed by a long period of institutional control; this is now being reduced to a 30-year period to reach an end-point to be agreed with key stakeholders. Investigations have suggested that the volume of radioactively contaminated material at shallow depth is up to 50,000 m<sup>3</sup>. Contamination is known to be present to more than 50 m below ground surface in competent rock, as a result of historic waste disposal.

By using a risk-management based remediation target, rather than an absolute concentration-based target, the amount of contaminated material to be disposed, and therefore the time and costs, could be reduced considerably. This will, however, leave substantial volumes of slightly contaminated material *in situ*.

There are two critical steps in implementing a risk-management based strategy: demonstrating to a sufficient degree of confidence that the risks remaining from this strategy are tolerable in the broad sense, and achieving regulator acceptance that statutory requirements have been met.

The amount of remediation on the site will depend on forthcoming government policy and on consultation with key local stakeholders.

### **INTRODUCTION**

#### **The Dounreay Experimental Nuclear Establishment**

The Dounreay Experimental Nuclear Establishment is located in Caithness, on the north coast of the Scottish mainland, Fig. 1. It is a sparsely populated area subject to severe weather. The largest town in the area, Thurso, has a population of <10,000 and is located 8 miles away. The predominant land-use in the vicinity is raising of pasture-fed beef cattle and sheep.



**Fig. 1. Location of Dounreay**

Construction of Dounreay started in 1955, with the objective of investigating the feasibility of fast reactors for power generation. By 1960 two reactors had been built and had achieved criticality: Dounreay Materials Testing Reactor (DMTR) was a low power uranium metal fuelled thermal reactor for experiments into material properties, and Dounreay Fast Reactor (DFR) was a uranium metal fuelled fast reactor with NaK coolant, rated at 60 MW thermal. Fuel elements for both reactors were fabricated and re-processed at Dounreay.

Construction of a third reactor, the Prototype Fast Reactor (PFR), was authorised in 1966 and it went critical in 1974. This reactor used mixed oxide fuel with a substantial plutonium content and sodium coolant, and achieved 600 MW thermal. The DFR re-processing plant was modified to re-process PFR fuel, though fuel element fabrication remained off-site.

In addition to the three reactors and the fuel reprocessing and manufacturing facilities, extensive laboratories were constructed and operated to support the reactor development programme, and there was also a large engineering workshop required for plant construction. The site is thus much more complex than a conventional nuclear power station.

Operation of the facilities generated radioactive and chemical wastes, which have been legally disposed on site in a variety of facilities, some of which are geological. The largest of these is an un-lined shaft into bedrock some 60 deep, containing a wide variety of intermediate level wastes. Although licensed, not all of these facilities are now considered to meet modern standards.

## **Decommissioning and Site Restoration Objectives and Context for the Management of Contaminated Land**

Reactor operations ceased in 1994, when it became clear that the uranium shortage that fast reactor technology had been developed to solve, was not imminent. Fuel reprocessing and manufacture continued for a period, but the last fuel elements were fabricated in March 2004. The establishment is now redundant and its sole function is to decommission itself as soon as practicable commensurate with achieving the necessary safety standards [1]. There is also an explicit requirement that resources should be used 'effectively, efficiently and economically' [1].

UKAEA published a suite of documents in 2000, known collectively as the Dounreay Site Restoration Plan (DSRP), which addressed the overall task of site decommissioning and restoration [2].

The restoration strategy (volume 2 of the DSRP) envisaged decommissioning and site restoration in three phases:

- **Decommissioning Phase** - involving decontamination, dismantling, demolition and remediation to an appropriate level protective of human health and the environment;
- **Care and Surveillance Phase** - during which residual radioactive material can be monitored to ensure long-term safety, and during which further radioactive decay will take place. The timescale for this phase is envisaged to be some 300 hundred years (which is based on the time for significant decay of some of the more important radionuclides to residual activity). At the end of this phase, most of the site will be de-licensable;
- **Post Restoration Phase** - where no institutional controls are assumed, other than normal Planning Authority controls, and the safe and environmentally acceptable condition of the site is justified through a post closure safety case.

The goals of this strategy for decommissioning and site restoration were to:

- ensure the safety of the public, the workforce and the environment;
- achieve value for money for the UK taxpayer;
- minimise waste production;
- gain the approval of Dounreay's stakeholders.

Although the condition of the site after the Decommissioning Phase had yet to be decided through consultation with the stakeholders, including the regulators and the public, it was anticipated that there would be some residual radioactivity and chemical substances left in the ground in the form of:

- residual contamination within building substructures;
- residual contamination from the remediation of the Dounreay Shaft;
- contaminated ground;
- closed inert landfill adjacent to the nuclear licensed boundary;
- possible on-site LLW disposal facilities.

At the end of the Care and Surveillance period (c. 2300), the site was expected to reach a Final Closure End Point, during which the risks to human health and the environment were sufficiently low to allow unrestricted further use of the site.

UKAEA is now revising its decommissioning strategy. It has proposed an Interim End State, achievable by 2036, where the site has been restored to 'brownfield' conditions, with waste present on site in a number of stores and possibly in a low level waste (LLW) repository. This proposal is made since there is currently no route for disposal of intermediate level waste, nor a timescale for building one. A 'brownfield' end is suggested since there is no pressure on land in sparsely populated Caithness.

This paper discusses how this reduced timescale for an Interim End State for contaminated land could be achieved and how these proposals interact with the current regulatory framework.

## **End State Criteria – UK Legislation**

### **Background**

Radiologically hazardous materials, and materials that are hazardous for other reasons, are generally regulated by completely separate legislation in the UK.

UK Nuclear sites are required to be licensed under the Nuclear Installations Act 1965 (NIA '65) and are regulated by the Nuclear Installations Inspectorate (NII), which is part of the UK Health and Safety Executive. Under the terms of these licences certain conditions are required to be met by site operators and guidance on compliance is issued by NII. Under the guidance for managing radioactive contaminated land, such land is to be treated as an accumulation of radioactive material in-situ and managed under a Safety Case [3]. The remediation of such land and its storage on a licensed site would also be regulated by the NII, although disposal would be regulated by a different environmental regulator – the Scottish Environment Protection Agency. UKAEA manages the contamination on the site to ensure that the risks to workers and the public are kept As Low as Reasonably Achievable (ALARA) and that there is no leak or escape of radioactive material (Licence condition 32).

A site licensed under NIA '65 cannot be de-licensed until the regulator is satisfied that there is "no danger" and has "ceased to be any danger" from radiation.

For other hazardous materials, the concept of contaminated land is explicitly recognised in the Part IIA of the Environmental Protection Act 1990, as amended by the Environment Act 1995 and implemented in Scotland by the Contaminated Land (Scotland) Regulations 2000. The test in these regulations is that action is required if there is 'significant risk' of 'significant harm' to human health and the environment (including surface water and groundwater). In considering the degree of contamination mitigation necessary, a cost-benefit test is available. Government has indicated an intention to bring radioactive contamination within this framework [4].

### **Consideration of Potential Clean-up Criteria**

The regulatory position outlined above means that restoration end points for contaminated land are either to meet:

- Delicensing criteria – such that the land can be released from regulatory control; or

- Site licence criteria – where the contaminated land is managed as an accumulation of radioactive material; or
- Disposal criteria – where the contaminated land is considered as a radioactive disposal and has to be authorised.

## **Approaches to Achieve the Above Criteria**

### *Risk Based Approaches*

Recent UK Government consultation on delicensing considers the criterion for “no danger” as to be interpreted as a residual risk of no greater than a 1 in a million chance of death per year from radiological exposure arising from any remaining man-made radioactivity left [5]. The Environment Agency, responsible for licensing repositories for the disposal of radioactive waste in England and Wales (but not Scotland), responded to this consultation suggesting that a risk of  $10^{-6}$  should be treated as a target rather than an absolute upper limit, indicating that there may be circumstances where achieving this target resulted in disproportionate cost, or non-radiological risks, for example the transport of very large quantities of slightly contaminated soil [6]. In their response, the Environment Agency also suggested that intervention should only be carried out if there is a net benefit, citing the European Basic Safety Standards Directive [7] (this legislation is yet to be incorporated fully into Scottish law).

In addition, other recent consultation on modernising the policy for decommissioning the UK’s Nuclear facilities recognises that restoration to “unrestricted reuse” may not always be the Best Practicable Environmental Option, and that the policy needs to be flexible enough to allow for a range of possible outcomes [1].

Tolerable levels of danger arising from disposed artificial radioactivity are discussed in the context of authorising radioactive waste disposal in [8]. This document is applicable for the whole of the United Kingdom. Best practicable means should be employed to ensure that the risk is ALARA. It is explicit that ALARA constitutes a balance between radiological and other factors, including social and economic factors. If the assessed risk is below the target of  $10^{-6}$ , no further reductions are necessary, but if above this target, it is necessary to show that reducing the risk is disproportionately difficult. There is, however, an indication that a predicted dose in excess of 0.3 mSv/y (equated to a risk of  $10^{-5}$ ) is not tolerable.

For chemically contaminated land, criteria in the UK for clean-up are based on best practicable means to reduce risk and remedy harm, as defined in statutory guidance issued under the Contaminated Land (Scotland) Regulations 2000 [9].

An alternative to risk-based clean-up criteria is to consider cleanup to an absolute level of radiation that is sufficiently low that a generic case of ‘no danger’ can be assumed in any circumstance. It should be noted that naturally occurring materials on the Dounreay site (phosphatic fossil fish), together with a recognisable signature from the Chernobyl accident, result in a background activity of 1 Bq/g total  $\alpha$ , 1.5 Bq/g total  $\beta$ , 1.0 Bq/g total  $\gamma$ , 0.02 Bq/g Cs-137 [2]. This would make cleanup to ‘no measurable radiation’ unfeasible.

The UK has defined a level below which material is exempt from regulation as radioactive material. This exemption level is set by the Substances of Low Activity Exemption Order (SoLA) 1986 and is  $<0.4$  Bq/g total man-made activity for materials substantially insoluble in

water. Thus a possible clean-up criterion is that all material exceeding 0.4 Bq/g artificial radionuclides is removed.

There are no longer any absolute criteria in use in the UK for remediation of chemical contamination.

## **ACHIEVING END STATE CRITERIA**

### **Contamination Inventory**

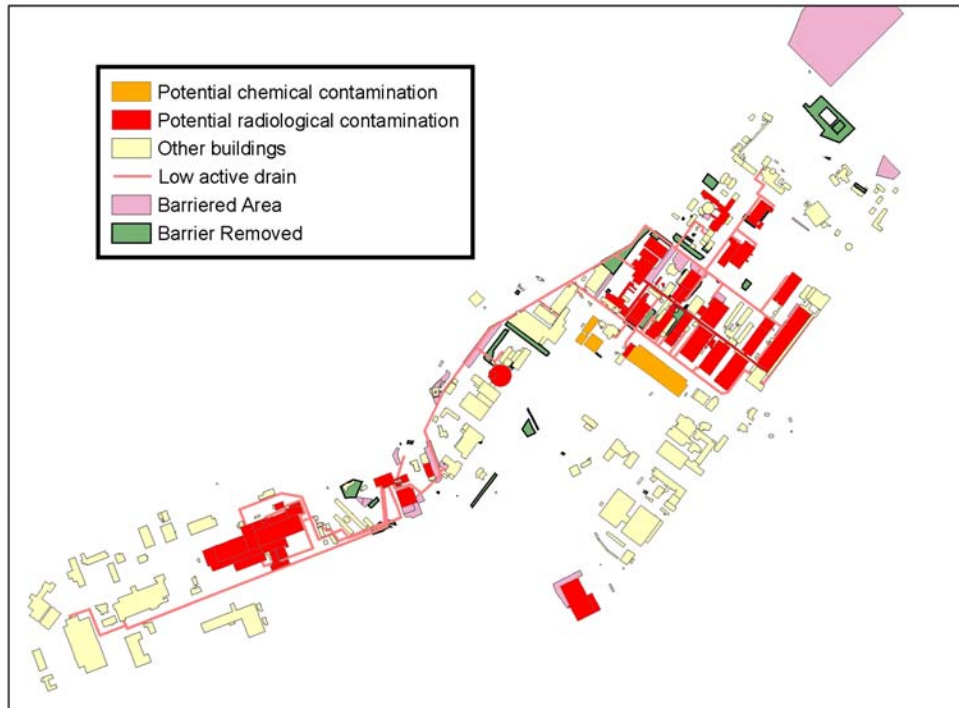
There is a long history of radiation monitoring of the Dounreay site, aimed mainly at ensuring the safety of site workers. This led to the identification of radioactively contaminated ground in various locations, some of which was associated with known incidents. A number of these locations have been remediated by excavation.

The nature and extent of chemical contamination has been less well defined than radioactive contamination. A systematic assessment of potential chemical and radioactive ground contamination, based on the operational history of the site, is now well advanced [10]. In addition to operational history, this is assimilating all the information acquired to date from both focused and opportunistic ground intrusions.

Most of this information relates to areas outside the confines of buildings. This situation will continue for several years, until plant de-commissioning is sufficiently advanced that it is possible to investigate beneath floor-slabs. Preliminary assessment of the likelihood of sub-floor contamination has been made on the basis of building use: sub-floor contamination is considered to be a higher risk in a building used for wet chemistry (e.g. dissolvers, laboratories) than for storage of dry material (e.g. stores for fuel elements).

Liquid effluent discharge from the process plants and the laboratories was and is managed via the Low Active Drain (LAD). Nowadays, discharge of active liquors is carefully managed and process liquors are generally separated and treated to reduce activity before discharge. However, practices were different in the past and leakage of active liquids from the LAD occurred. The early LAD was eventually made redundant and sections either removed or entombed in concrete, being replaced by high integrity piping with secondary containment, installed in the original duct. However, the early leaks from the LAD have left a legacy of radioactive ground contamination in a number of areas adjacent to the LAD.

An indicative view of the location of known or possible contamination is presented in Fig. 2. In general, contamination associated with buildings remains to be confirmed.



**Fig. 2. Potentially contaminated locations on the Dounreay site.**

Based on this indicative view, radioactively contaminated ground is conservatively assessed as amounting to up to 50,000 m<sup>3</sup> of radioactive material. Of this, up to 40,000 m<sup>3</sup> is expected to be below 40 Bq/g and around 10,000 m<sup>3</sup> is expected to be between 40 Bq/g and a few hundred Bq/g. The dominant nuclides (in decreasing order) are believed to be Cs-137, Pu-241, Sr-90, Pu-239/240, Pu-238 and Am-241.

Information so far indicates that this contamination is present in unconsolidated Quaternary sediments and made ground, that are typically 1-2 m thick but up to 10 m thick in a few locations. Contamination along fracture planes in the underlying Devonian siltstones and sandstones is known to be present in the vicinity of the waste disposal shaft to a depth of 50 m below sea level and cannot be ruled out elsewhere.

Currently, there is only a preliminary inventory of chemically contaminated land.

### **Risk Assessment**

Hazard and risk assessments of the radiological risks arising from contaminated land at Dounreay has been carried out in the context of managing the current contaminated land holding during the Decommissioning Phase of the site [2] and with respect to the post-decommissioning evolution of the site.

These assessments were carried out using a compartment modelling approach incorporating direct irradiation, ingestion and inhalation pathways. Consistent with the current operation of the site, potentially exposed groups (PEGs) were identified as:

- Site worker, working outside;
- Contaminated land surveyor;
- Foreshore surveyor;
- Office worker inadvertently sited in a high exposure area;
- Worker inadvertently excavating contaminated area;
- Farmer adjacent to the site;
- Foreshore fisherman adjacent to the site.

Predicted dose rates are given in Table I.

**Table I. Peak Dose Rates To Potentially Exposed Groups At Dounreay For Mean Contamination Inventory**

Potentially exposed group	Peak dose rate (mSv/yr)	Time of peak dose (yrs after model start)
Outside worker	0.002	19
Contaminated land surveyor	0.19	0
Foreshore surveyor	0.0000017	50
Inadvertent exposure of office worker	3.6	0
Inadvertent excavation	0.24	0
Farmer	0.000037	>360
Foreshore fisherman	0.00000015	50

These dose rates can be compared with the dose constraint for a licensed radioactive waste repository of 0.3 mSv/year to a member of the critical group. For most PEGs, the received dose is several orders of magnitude less than this dose constraint. It is exceeded for only one, and is of the same order of magnitude for two. The contaminated land surveyor has a pattern of exposure unlikely to exist outside the context of a nuclear licensed site – deliberate visits to known contaminated areas, although taking appropriate precautions. Detailed analysis of the pathways shows that most of the dose comes from direct irradiation. The high dose to the office worker (theoretically working in temporary accommodation inadvertently located over a significantly contaminated area) also results from direct irradiation by Cs-137. Pathways that involve migration through the environment, which produces a degree of spatial averaging, result in much lower doses, e.g. the farmer. The pathway is through the ingestion of crops and animal products and the dominant nuclide is Am-241.

For the post-decommissioning period, potentially exposed groups were identified as:

- Farmer and a crofter working on the land on the site and eating the produce;
- Excavation intruders who dig in areas of contamination on the site;
- Persons living in an area contaminated from material excavated from the site.



The post-decommissioning hazard and risk assessment modelling also considers the effect of different site end points with respect to contaminated land. Thus the model considers leaving contamination in-place, and also removal to a level of 0.4 Bq/g.

In the post-decommissioning period, with no removal of contamination, the most significant exposures would also be by the inadvertent occupancy of an area of contaminated land, and to a lesser extent, by inadvertent excavation.

Understanding of chemically contaminated land at Dounreay is not sufficiently advanced for any general numerical assessment of risk to be made, although risks from specific issues have been addressed. Nothing classified as 'significant' has so far been encountered.

## **Restoration Strategies**

### *Possible Restoration Strategies*

A number of possible standalone restoration strategies for radioactively contaminated land can be conceived, including:

- Do nothing but institutional control;
- Limited source removal;
- Application of clean cover;
- Complete source removal.

These are discussed below, together with the implications from the modeling. For clarity, the discussion ignores the need to integrate the strategy in detail with other aspects of site decommissioning, although this is clearly important in achieving best value and an optimised time.

### *Do nothing but institutional control*

The results from modeling show that for the site in its current condition hazards exist which could potentially lead to unacceptable exposures as a consequence of "accident" conditions such as inadvertent occupancy or inadvertent excavation of contaminated land. The Care and Surveillance described in DSRP could provide land use restrictions sufficient to reduce these risks. However this approach will not enable all areas of the site to meet the "unrestricted reuse" criteria for closure until all short-lived nuclides have decayed, nominally 10 half-lives, 300 years for the most significant contaminating radionuclide, Cs-137.

It should be noted that the "Do Nothing" approach has no effect on doses and human health risks to external PEGs such as the farmer but these are already well within regulatory constraints and may not need action.

Institutional controls for >100 years are probably relatively cheap for the current generation but may be perceived to impose a significant burden on future generations and cannot therefore be guaranteed to gain public and regulator acceptability as the primary method of managing the contaminated land.

### *Limited source removal*

The highest dose rates associated with contaminated land arise from a very small part of the site, and are mostly associated with relatively shallow unconsolidated sediments along the LAD and around the old effluent treatment plant. Removal of contaminated unconsolidated sediments during the decommissioning of these facilities should be a relatively straightforward task. The volume of material to be removed will be determined by the target activity permitted to remain – that remaining likely to be in the 0.4-40 Bq/g range and that removed being above 40 Bq/g. In practice, this is likely to mean excavating material, assaying it and sentencing material above the predetermined threshold to waste, returning the remainder whence it came. There is also likely to be some contamination associated with fissures in the underlying bedrock, possibly over 40 Bq/g on fracture surfaces. However, breaking out this material can be physically difficult and involves removing a large volume of uncontaminated material in the process. Modeling shows that leaving this deep material in place does not lead risks to human health of  $>10^{-6}$ .

Determining the optimum amount of material to be removed will require simultaneous optimisation of risk and cost, to meet the ALARA criterion. It seems likely that removal of unconsolidated material but not bedrock will be ALARA. Using a threshold of 40 Bq/g, the volume of unconsolidated material to be removed as waste is estimated to be  $\sim 10,000 \text{ m}^3$ .

Excavation is relatively quick and can be integrated into the decommissioning activities of the associated facilities. Selective excavation will also avoid significant inter-generational issues. However, it is likely to prove more expensive than institutional control, and also generates radioactive waste, which has an associated significant disposal cost.

#### *Application of clean cover*

A nominal one metre of compacted crushed rock or crushed exempt rubble from the demolition of buildings, will provide more than sufficient shielding to reduce the direct irradiation from the more heavily contaminated areas of the site down to a tolerable level, and provides a significant degree of physical isolation from possible disturbance. By isolating contaminated materials from the surface environment, it will also eliminate the dust-inhalation pathway that is the next most significant. It will have less effect on the external PEGs, since the source is not reduced, and the groundwater pathway is not significantly affected. However, the risks to external PEGs from existing contaminated land are already well within regulatory constraints. It will isolate any possible subsequent agricultural use of the site from the contamination.

There may be some subjective objection to this proposal, as this option appears to be covering a problem rather than solving it.

#### *Complete source removal*

This would involve removal of all material having an activity above some pre-determined limit such as the 0.4 Bq/g SoLA Exemption limit. There is no estimate of the volume of material exceeding this criterion – the volume of soil alone is estimated to be up to  $50,000 \text{ m}^3$ . To this volume must be added the volume of material to be excavated to get at the contaminated material present as fracture coatings in rock. There is evidence of groundwater circulation to  $>10 \text{ m}$  depth. Excavation to 10 m depth would involve moving  $1.5 \text{ Mm}^3$  of material, largely intact rock. Clearly, excavation of this large volume of rock will take longer than the  $10,000 \text{ m}^3$  of unconsolidated material considered under limited source removal.

This approach would meet all the restoration targets considered above. The excavation work, even on this large scale, would be completed in considerably less than 100 years. The costs

would be substantial, and the result would be a very large volume of very low activity waste. Because of the scale of the operation, this approach has the greatest risk of negative environmental consequences.

### *Chemical contamination*

There are more potential remedial techniques available for chemical contamination, and therefore it is expected that a wider range of options will need to be considered once characterisation has advanced to the stage that optioneering is possible. The range of remedial options for chemical contamination includes source removal (or destruction in place), various forms of pathway interruption, through to natural attenuation (do nothing but monitor). These are consistent with the approaches outlined above for radioactive contamination.

### **Preferred restoration strategy**

'Do nothing but institutional control', although cheap, is very time consuming. Under this scenario, the whole of the existing site would remain regulated as a nuclear licensed site for ~300 years. It may not be acceptable in social consequences, because it transfers liability between generations when other practicable approaches exist for this generation.

'Complete source removal' will be very expensive and it is not clear that it minimises the overall risk to human health and the environment. There is still a risk from the large amount of material removed to a repository, and there is significant environmental effect from the re-location of very large quantities of material.

Both 'limited source removal' and 'application of clean cover' have the potential to meet risk-based remedial targets, but not absolute targets. Both could be achieved at moderate cost and over relatively short timescales, and are therefore contenders for 'as soon as practicable'. Source removal to any degree in particular must reduce the risk from the Dounreay site, provided that the source material is removed to an appropriate repository – i.e. one from which the risk is lower than that from the material *in situ*. Clean cover provides shielding and mechanical isolation. In addition, an adequate thickness of crushed stone or clean decommissioning rubble will render residual contamination inaccessible without heavy equipment, and could place it below the normal level of excavation for infrastructure associated with any re-development. It will also provide a surface suitable for a range of future site uses, other than agriculture. The above two approaches for radioactively contaminated land are consistent with current guidance for chemically contaminated land, which focuses on risk reduction, subject to not incurring disproportionate cost. Risk reduction can be achieved either by source reduction or pathway removal.

Having reduced the risk to perceived public receptors to a tolerable level, the decision remains as to whether the site would still need to be managed as a nuclear licensed site, with measures to exclude the public. It would be prudent to continue a degree of monitoring, but more relaxed institutional control over the restored parts of the site may be appropriate.

The proposed risk management based approach, by reducing the amount of waste to be removed and disposed, reduces the time and the cost of restoration while meeting accepted risk targets. It also avoids the delays that would be associated with constructing a suitable large repository for the wastes that would be produced by remediating to 0.4 Bq/g.

## **TAKING THE STRATEGY FORWARD**

### **Demonstration of tolerability**

For the approach described above to be tolerable, it must meet several criteria:

- The residual risk to human health and the environment must be tolerable;
- There must be a net radiological benefit, i.e. the risk from the waste removed to a repository must be less than that it imposed while in situ;
- Any net environmental detriment from restoration should be minimised;
- It should be an acceptable solution to the current generation, without being less acceptable by the same criteria to a future generation.

To demonstrate the above will require a performance assessment of the proposed remedial target, which may be a combination of activity and volume. This will need comparing with at least an outline performance assessment of the repository proposed for the produced waste, to show that removal to a repository will produce a net radiological benefit. The performance assessment will be only a part of the safety case – UK government policy requires a holistic approach taking into account risk to this and future generations and overall environmental benefit. A consultative assessment of options for site closure is planned for the future, which will consider the overall decommissioning and restoration strategy for the site – not just the strategy for contaminated land. This consultative assessment will be based on the Best Practicable Environmental Option (BPEO) process and will include public consultation. UKAEA Dounreay has already established by consultation that leaving residual radioactivity in the ground from the restoration of the waste shaft can be acceptable to the public [11]. It is not clear that the least overall radiological consequence and the least environmental disturbance will occur simultaneously. There appears to be no clear guidance to resolve this. However, the BPEO can perhaps be considered as a balance between radiological issues, environmental issues and cost. It seems likely that the residual risk will be so far below the current dose constraint that there will be flexibility in demonstrating the radiological aspect of ALARA.

### **Achieving regulator acceptance**

The proposed approach involves planning to leave material known to be radioactively contaminated above exemption limits, in the ground, not in an engineered repository, as its final resting place. It would currently require to be authorised as a disposal, despite the lack of engineering measures in achieving the disposal. This appears to be legally possible, as long as the risk target of  $10^{-6}$  discussed above can be achieved. If the logic is followed, there is no clear reason why the existing stocks of excavated HVLA material, currently held in stores, should not be replaced in the ground. There is currently no precedent for this in the UK, although it follows logically from accepted principles. However, there is legislation that could be interpreted to hold that this approach, although apparently desirable in meeting the overall restoration target, is illegal, and this interpretation is current practice in Scotland.

There is developing consistency in the principles underlying management of radioactively contaminated land, and repositories for radioactive waste. Regulators need to make sure that these common principles are translated into consistent regulation and guidance. The definition

of radioactively contaminated land *in situ* as waste causes problems in management, and differs from the way that chemically contaminated land is treated. Currently, nuclear licensed sites (such as Dounreay) and radioactive waste repositories are regulated under different legislation by different regulators. There is thus the possibility of inconsistencies in regulation.

Regulator acceptance is clearly essential to achieving the time and costs savings in site restoration that are potentially available using a risk-management based end-point. There is time for dialogue with regulators to occur to achieve the necessary consensus. UKAEA is involving regulators and other stakeholders in this dialogue.

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