Dounreay Site's Interim End State-Environmental Safety Strategy – 17509

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ABSTRACT

The Dounreay nuclear licensed site, located in Caithness on the north coast of Scotland, was the United Kingdom's (UK) site for Fast Reactor research and development. The Dounreay facilities are now being decommissioned and the site restored in accordance with UK Government policy to manage civil nuclear liabilities. This site closure and environmental restoration programme is to achieve levels of residual radiological and chemical contamination sufficiently low that the site will be safe for future use. This document sets out the Environmental Safety Strategy for the site remediation and closure programme, which will follow completion of facility decommissioning and demolition.

The document summarises the contractual definition of the Dounreay site end states and also the associated regulatory regimes. An overview of the approach and processes for achieving the Interim End State (IES) are provided, along with consideration of how Dounreay will demonstrate that the IES has been achieved.

INTRODUCTION

The Dounreay nuclear licensed site, located in Caithness on the north coast of Scotland (Fig. 1), was the United Kingdom's (UK) site for Fast Reactor research and development. The Dounreay facilities are now being decommissioned and the site restored in accordance with UK Government policy to manage civil nuclear liabilities. This site closure and environmental restoration programme is being undertaken by Dounreay Site Restoration Limited (DSRL) and the Cavendish Dounreay Partnership (CDP) Limited (hereafter referred to as 'Dounreay') under contract to the Nuclear Decommissioning Authority (NDA). The NDA is the UK Government non-departmental body responsible for managing the UK civil nuclear liabilities.

The overall objective of the site closure and environmental restoration programme is to achieve levels of residual radiological and chemical contamination sufficiently low that the site will be safe for future use. An overall approach to achieving this objective is set out in the contract between Dounreay and NDA. This document outlines the Environmental Safety Strategy (ESS) developed by Dounreay to achieve this objective. The ESS is based on a remediation programme that will be undertaken following the completion of decommissioning and demolition of facilities.

The contract between Dounreay and NDA envisages that the remediation programme will result in the site achieving a condition termed the Interim End State (IES) by 2033. Following this, there will be an extended period when conditioned higher activity wastes (HAW) will be stored on site and authorised disposals of low level wastes (LLW) and demolition LLW (DLLW) will be completed at D3100 Disposal Site.

During this period of institutional control, no further remediation or restoration activities on the site are anticipated although attenuation and radioactive decay will continue to reduce the concentration of contaminants. Routine operations and periodic re-building of the HAW stores may be required during this period, but after some 300 years the HAW and associated stores will have been removed and the Final End State (FES) will be achieved allowing unrestricted use of the site.

This document provides a summary of the following:

- Regulatory regimes relating to closure of a nuclear licensed site that applies at Dounreay;
- IES and FES states as defined in the contract between Dounreay and NDA and the processes through which these end states may be reviewed and modified;
- Processes through which the end states will be achieved, including an outline of the Environmental Restoration Programme Plan (ERPP);
- Documents and processes that will be used to provide assurance that the end states have been met; and
- Management processes and practices that will be applied throughout the implementation of the ESS.

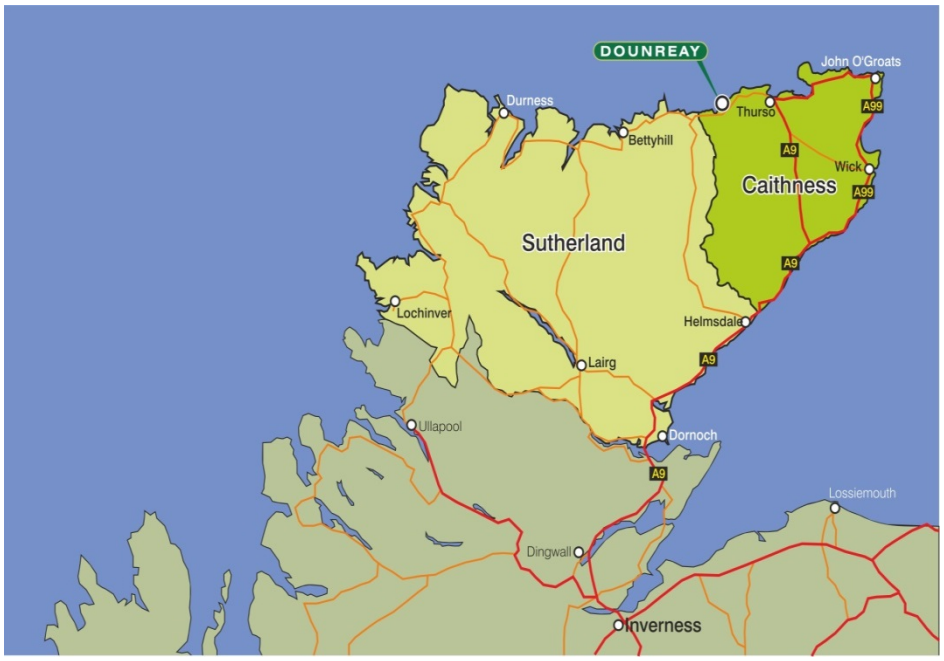

Fig. 1. Location of Dounreay

REGULATORY REGIMES

There is a series of regulations relevant to the closure and environmental restoration of nuclear sites. The Safegrounds report “The UK regulatory framework for contaminated land on nuclear-licensed sites and defence sites” [1] provides an overview of the relevant regulations, although there have been developments in the interpretation and associated guidance since publication. The summary of regulatory regimes in this section outlines the regulation of the nuclear licensed site, the requirements relating to the disposal of radioactive waste, groundwater protection, and planning considerations. There are further regulations applying to the site and operations during remediation and the period of institutional control but these do not affect the definition of site end states or the overall strategy.

Nuclear Installations Act 1965

The Dounreay site is subject to a nuclear site licence under the Nuclear Installations Act 1965 (NIA65), which is regulated by the Office for Nuclear Regulation (ONR). ONR uses the Safety Assessment Principles for Nuclear Facilities [2] and supporting Technical Assessment Guides as assessment tools to support their regulation of the nuclear licensed site. ONR's responsibilities include the regulation of radioactively contaminated land and groundwater on nuclear licensed sites.

Land Quality Management (LQM(refers to the prevention of contamination of both land and groundwater, and extends to remediation (including control and monitoring) of contamination on the surface of the ground, in the ground, and in groundwater. ONR works jointly with Scottish Environmental Protection Agency (SEPA) on matters of land quality and has adopted similar definitions of radioactive material and radioactive waste to those used for radioactively contaminated land and groundwater outside of licensed sites.

A nuclear site licence is granted for an indefinite period to a specific corporate body [3, p.14]. Variations to extend the site or to exclude parts of a site no longer required for licensable activities may be made. A licence may be revoked by ONR or surrendered by the licensee, but the licensee may be required to retain certain responsibilities for the site. The ending of the "period of responsibility" requires ONR to be satisfied that there has ceased to be any danger from ionising radiations from anything on the site (the "no danger" criterion).

ONR has published a policy statement [4] and additional guidance [5,6] on how it interprets the "no danger" criterion. Any residual radioactivity above the average natural background, which can be satisfactorily demonstrated to pose a risk of death to the most exposed individual of less than one in a million per year is "broadly acceptable" and thus represents "no danger". Compliance with this criterion will normally mean that ONR can de-license the site and that licensee has no further responsibilities for the site.

Under the current regime, compliance with the ONR "no danger" criterion might prevent leaving RSA 93 authorised disposals on a site at de-licensing. The criteria and exposure scenarios used by the environment agencies to assess a waste disposal site are different from those used for de-licensing by ONR. In particular, the environment agencies assess the effects of future intrusion into a waste disposal site using a dose criterion rather than a risk criterion. The NDA, Environment Agency, SEPA and ONR are currently holding discussions with the UK Government and devolved administrations' Radioactive Substances Policy Group (RSPG) with regard to issues relating to nuclear site restoration. There is a possibility of changes in the "no danger" criterion and its application.

Radioactive Substances Act 1993

The Dounreay site has an authorisation for the accumulation and disposal of radioactive waste under the Radioactive Substances Act 1993 (RSA 93), granted by SEPA. During site operations and remediation, the authorisation allows for the disposal of solid radioactive waste by transfer to a waste permitted person, the discharge of liquid wastes to the sea, and gaseous discharges to atmosphere.

When there is no further need for the site to be regulated under any of SEPA's powers, the authorisation will be revoked. Interim guidance on the requirements for revocation of an RSA 93 authorisation (GRR) has been developed by SEPA pending the production of detailed guidance. Part 1 of this revocation guidance requires the site to be returned to a "satisfactory state" [7]. Part 2 of the guidance introduces the requirement for a Site-Wide

Environmental Safety Case (SWESC) to demonstrate that the Authorised Premises have been returned to a satisfactory state [8]. Only after this demonstration will SEPA revoke an Authorisation.

Groundwater Daughter Directive

At Dounreay, SEPA is also the responsible body for regulating inputs of pollutants to groundwater. There are two European Community (EC) Directives affecting groundwater: Directive 2000/60/EC (the Water Framework Directive or WFD), and Directive 2000/118/EC (the Groundwater Daughter Directive or GWDD). The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR) were introduced to help achieve the objectives of the WFD. At Dounreay activities authorised under RSA 93 are deemed to be authorised under CAR and therefore to be compliant with the requirements of the WFD and GWDD.

SEPA has developed guidance [9] on how the prevent and limit requirements of the WFD should be applied to assess potentially polluting high risk point sources inputs of pollutants into groundwater. The guidance also explains how exemptions to the requirement might be applied. More specific guidance on the application of the WFD and GWDD requirements during remediation of the Dounreay site is provided in correspondence between SEPA and DSRL. This site-specific guidance is currently assumed to have the same legal weight as published guidance, but dialogue with SEPA will continue throughout the remediation process and changes to the application of the requirements may occur.

Compliance with the requirements of the WFD and GWDD forms part of Dounreay's LQM process during site remediation. Because of the relationship between CAR and RSA 93, a demonstration of this compliance will also be required for revocation of the RSA 93 authorisation.

Planning

Planning decisions regarding the use of the Dounreay site are the responsibility of the Highland Council. The Highland-wide Local Development Plan (HwLDP) is supplemented by the Dounreay Planning Framework 2 (DPF2) [10] which presents an expectation that, at the Interim End Point (IEP) "*land [will be] decontaminated to a point where it is possible to identify, and optimise the amount of, land suitable and available for reuse as an industrial/business site while not adversely affecting the integrity of the Caithness and Sutherland Peatlands SPA [Special Protection Area]/Ramsar, the Caithness Lochs SPA/Ramsar and the North Caithness Cliffs SPA*."

A perspective of the likely next planned use(s) for NDA sites considered the physical characteristics of each site and a number of external factors, including national (UK and Scottish) policy and the local planning policy. At Dounreay, the study identified oil and gas rig decommissioning and renewable energy generation as potential commercial uses. In addition, the generic land use assessment in [11] identified agriculture and other uses similar to those considered in the risk assessments supporting DSRL's remediation plans. DPF2 recognises that any future changes to land use will need to be compatible with any ongoing regulatory requirements after the IEP, and that this may limit the changes that are possible and the timing of any change.

SITE END STATES

The NDA is required by the UK Government to describe the condition to which designated land and its associated structures and infrastructure need to be restored - the Site End State [11, §3.1.3]. A Site End State describes objectives for ongoing management of structures, infrastructure and land quality as well as having implications for the management of waste, spent fuels and nuclear materials arising from operations and site restoration activities.

In the case of Dounreay, two Site End States are defined in the contract between NDA and Dounreay, the IES and the FES. The overall objective of the site closure and environmental restoration programme is to meet the requirements for ending the period of responsibility under the nuclear site licence such that the site will be available for unrestricted use. This condition, defined in the contract as the FES, is the point at which the “no danger” criterion in NIA65 is fulfilled. The time at which it is scheduled to be achieved, the Final End Point (FEP), is 2333.

Meeting the “no danger” criterion at the FES will require removal of all HAW stored on the site and the demolition of structures to foundation plinth level. Any residual radioactivity above the average natural background must be low enough that the risk of death to the most exposed individual is less than one in a million per year. The levels of activity that satisfy the “no danger” criterion at the FES can be achieved through radioactive decay and attenuation of higher contamination levels over a period of time.

The IES is defined in the contract as the state at which any contamination left in the ground or detected in groundwater will be capable of meeting the “no danger” criterion by the FES in 2333 without further remediation activity. In the period between the IES and the FES, the site will be under institutional control. The assumptions underlying the definitions of the IES and the FES are illustrated in Fig. 2.

Although there is no regulatory definition of the IES, and thus no mechanism for regulatory agreement on this milestone, it is necessary to demonstrate that any residual contamination cannot pose an unacceptable risk between IEP and FEP, assuming reasonably foreseeable land use during this period. Documenting the IES will demonstrate that a robust set of processes have been followed and will provide evidence that remediation activities have been undertaken to a standard that will satisfy the NDA that contractual requirements have been met.

Management controls will remain in place during the period of institutional control between IEP and FEP, in order to satisfy the requirements of the nuclear site licence. The site will also remain an Authorised site under RSA 93 during the period of institutional control, and as such will be subject to the appropriate dose constraint, as well as the requirement to demonstrate that any doses are optimised. Non-radiological impacts on the environment would also continue to be regulated, most notably under CAR. Documenting the IES will support a demonstration that these regulatory requirements can be met but will not require specific regulatory approval.

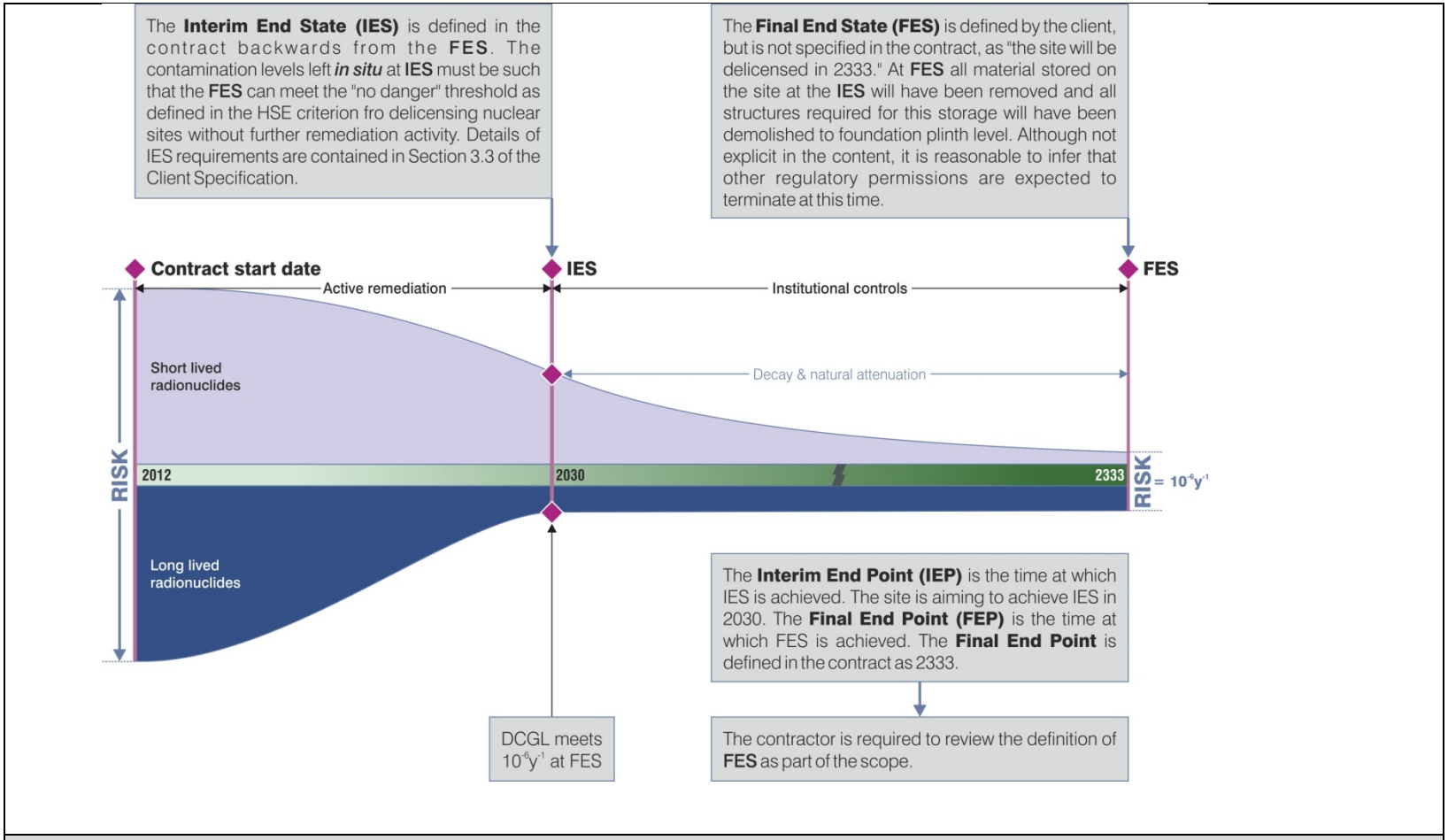

Fig. 2. In order to achieve IES, it must be demonstrated that the "no danger" criterion can be achieved at FES, without further remedial action. (NB The 300 years indicated is an approximation; the FES will be achieved at 2333.)

More detailed objectives and requirements relevant to the closure and restoration programme are detailed in the NDA's Client Specification, the document which forms the basis of the contract between the NDA and Dounreay. They are summarised as follows:

- All structures with the exception of those required for continued site operation (which include the HAW Stores and the Police Command and Control Building) are to be removed to the level of the foundation plinths. Foundation surfaces are to be free from potentially mobile contamination. Residual contamination levels are to be low enough to satisfy the "no danger" criterion at FES and to satisfy all regulatory requirements.

- Concrete substructures, which are not part of building foundations, e.g. secondary containment or underground cells, may also be left in situ, provided they meet the same requirements as the foundations. Any ancillary metalwork (e.g. cell linings, pipework, and tank supports) must, however, be removed.

- Any voids left by the removal of foundations are to be backfilled.

- Drains and underground services are to be left in situ, providing the contamination levels are low enough to satisfy the FES requirements (including any risks from inadvertent human intrusion). Cables are to be demonstrated to be safe.

- Adequate drainage is to be in place to manage future surface water run-off.

- All roads and pathways are to be left in situ, providing contamination levels are low enough to satisfy the FES requirements.

- Soft landscaping is to be undertaken prior to IES to ensure that the restored site blends in with the local environment. All disturbed land (excluding foundation slabs and roads) is to be coated with top soil and re-seeded with native vegetation.

The contract requires Dounreay to periodically review opportunities for an alternative IES and / or FES and to notify the NDA of any areas of the IES and / or FES that could be optimised to deliver the contract in a more efficient manner. Dounreay undertook an optimisation review in 2013 and is embarking on a review of the Site End State options to determine what might be the preferred option should the options be unconstrained by current regulatory guidance and policy positions.

ACHIEVING SITE END STATES

Achieving the IES is a step-wise process requiring characterisation, demolition, remediation, verification, restoration and the ongoing maintenance of land quality. Active remediation will cease at the IEP and radioactive decay and natural attenuation will then reduce any residual contamination to levels that pose "no danger" at the FEP.

Remediation Targets

A key component of the environmental strategy is the derivation of remediation targets for the IES that will ensure that radionuclides that remain in the ground will meet the "no danger" criterion at the FEP. Quantitative modelling has been used to derive suites of concentration levels for individual radionuclides that will meet this criterion. These Derived Concentration Guideline Levels (DCGLs) [12] are based on models and parameter values selected to be reasonably conservative and hence ensure that regulatory requirements will be met.

The DCGLs correspond to additional risks and, for use as remediation targets, must be added to background concentrations. Background concentrations (Environmental Reference Concentrations) have been determined through off-site characterisation. Remediation targets will be set to ensure that average radionuclide concentrations remaining at IEP meet the DCGLs.

DSRL has discussed the modelling methodology with SEPA and ONR. SEPA have acknowledged that the use of a reference scenario, considering all relevant exposure pathways to a family crofting on the site after FES, is an adequately conservative approach, in terms of site use, where a heterogeneous distribution of radioactive contamination is assumed. DSRL will continue dialogue with SEPA and ONR on the use of DCGLs as they are applied during remediation activities to ensure there is minimal risk of having to revise these targets and revisit work. DSRL anticipate the need to review the models that underpin the DCGLs as the programme progresses and additional site characterisation information becomes available.

Remediation criteria based on minimum reporting values (MRVs) are also needed to fulfil the requirements of the GWDD and to demonstrate that “all measures necessary to prevent inputs into groundwater of hazardous substances” have been undertaken. MRVs are generally defined as the lowest concentration of a substance that can be routinely determined with a known degree of confidence and will provide the basis for remediation targets for chemical contaminants.

Zoned Approach to Achieving the IES

The site has been divided into a series of zones to facilitate a methodical, efficient and cost-effective approach to building demolition, characterisation and remediation activities (Fig. 3). Following the completion of remediation across all zones, restoration, including final landscaping, is currently scheduled to be undertaken as a single pass, site-wide activity at the end of the programme.

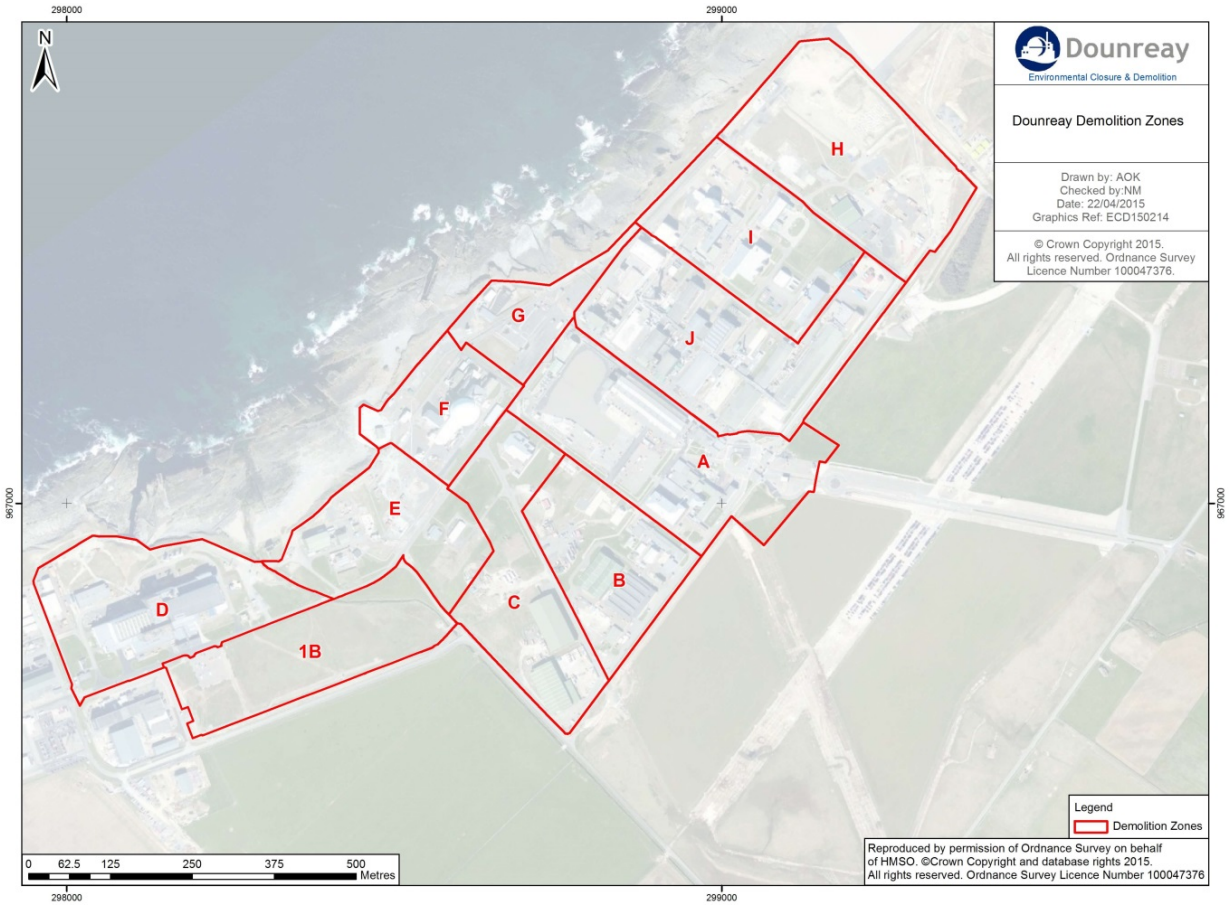

Fig. 3. Site zones (labelled 1B and A to J)

The original strategy envisaged demolition and remediation work being sequenced to minimise the risk of recontamination and re-work, with less contaminated zones dealt with first. This approach would allow the process to be proved, lessons learned and confidence built. The current approach, however, is for the majority of the activities to be undertaken in parallel in different zones, within a compressed period at the end of the entire programme (Figure 4). There is a risk with this approach, as there is limited opportunity for process improvement and skills development. Furthermore, there is little flexibility within the programme to respond to any issues or additional requirements that will arise during the characterisation and remediation work.

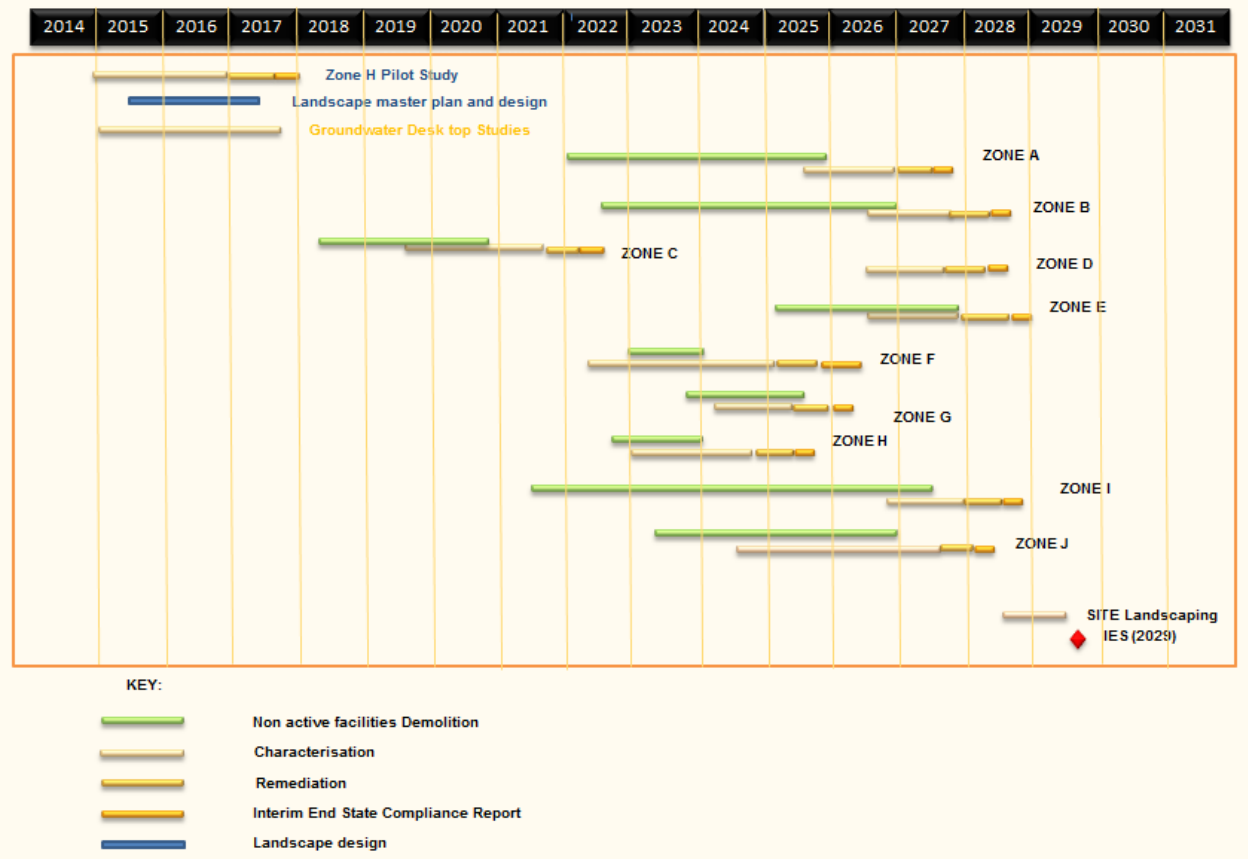

Fig. 4. Summary schedule for site remediation

The processes involved in characterisation, remediation and restoration have been trialled initially on Zone 1B in discussion with the regulators. Further trials will be conducted in individual 'study areas', where and when opportunities become available. An initial trial is being undertaken with a study area in Zone H. Characterisation and an assessment of closure options for the Liquid Effluent Discharge System also allow processes to be trialled, while allowing the potential for in situ disposal of radioactive waste to be examined.

The scheduling of characterisation activities must recognise that the 'prevent and limit' requirements of the GWDD need to be addressed as soon as is reasonably practicable. Early characterisation in order to assess potential impacts to groundwater is therefore planned (Fig. 4).

It is recognised that site infrastructure networks cross the zone boundaries. A strategy is being prepared to ensure that service disruptions will not occur due to the zoned approach to closure.

Environmental Restoration Programme Plan

Achieving the IES in a robust and cost-effective manner requires the integration of the decommissioning, demolition and restoration programmes. The ERPP sets out a "road map" which will be followed from the site's current state to the IES (Fig. 5).

The ERPP and the key processes required to achieve the IES are summarised in following pages. Documentation of the restoration programme is an important element of providing assurance that the IES is achieved. The ERPP aim is to ensure that Dounreay can

demonstrate that the processes used in restoration are robust and thereby provide assurance and confidence in the restoration programme. Evidence collected during the application of these processes will underpin the arguments and justifications to be laid out in SWESC.

The ERPP defines the approaches for characterisation of the ground and remaining infrastructure, necessary remediation, and restoration. It also provides details of other supporting activities, such as data and record management. The ERPP is consistent with the requirements of the Environment Agency's 2004 guidance, "*Model Procedures for the Management of Land Contamination*" (CLR11) [13] that is endorsed by SEPA and it takes into account guidance issued by the Safegrounds learning network.

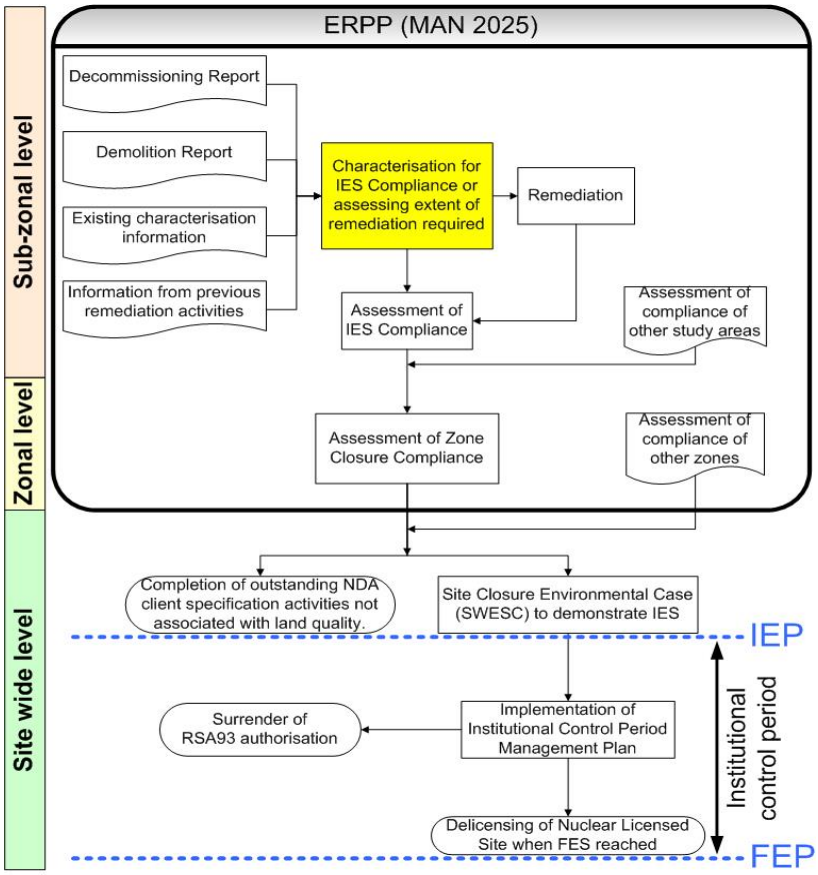

Fig. 5. Overview of the ERPP

Characterisation

Characterisation is an iterative process and will be required at several stages in the remediation programme. Initial scoping characterisation is to develop a conceptual model, to define the extent of remediation that is required on the site. The last of these stages is verification sampling that will provide information that demonstrates that study areas are compliant with the IES requirements.

Characterisation will be undertaken in a systematic manner, utilising best practice processes and techniques, for example the Safegrounds Good Practice Guidance on Site Characterisation [14]. An audit of the ERPP against Safegrounds guidance concluded that the ERPP process adheres to the guidance and may therefore be relied upon to appropriately characterise the site.

Characterisation will be undertaken at different times and at different scales. Some of the key drivers for characterisation at different programme stages are illustrated in Fig. 6.

	Decommissioning	Demolition	Remediation	Restoration
Primary Drivers for characterisation	• H&S protection • Waste routing	• Waste routing • H&S protection • End State scoping	• End state attainment • Waste routing • H&S protection	End State demonstration
Primary objectives of characterisation	Safe removal & disposal of high active components and process equipment	Compliant routing of low activity building demolition waste	Removal of land and treatment of groundwater above the clean-up levels	Assurance that no contamination is re-introduced through imported material
Primary media being characterised	• Components • Process residues • Process areas	• Building debris • Concrete slabs	• Concrete slabs • Land • Groundwater	Land contouring and void filling material
Primary characterisation techniques (inc for verification)	• Hand held rad surveys • NDA • (High LoD)	• Hand held rad surveys • Chemical PID • NDA of cores • (Low LoD)	• Hand held rad surveys • Drive-over rad surveys • Chemical lab analysis for Low LoD and verification of DCGLs etc.	Verification of supplier QC processes for imported materials
Primary waste types	ILW / LLW / OOS	LLW / OOS	LLW / OOS	None

Fig. 6. Life Cycle Characterisation

Early characterisation is important for confirming, or otherwise, the assumptions regarding the volumes of different waste categories that may arise from remediation activities. Any increase in waste storage or disposal requirements arising from these and any other changes in waste volumes must be determined early in the programme if the necessary waste routes are to be available prior to the IEP. The occurrence of mixed contamination, i.e. radiological and non-radiological, may also require consideration of alternative waste routes. Decommissioning projects intending to leave infrastructure and sub-structures within the ground will also need to undertake characterisation in order to demonstrate that the IES requirements can be met.
Characterisation to define the extent of contamination will involve:

- Evaluation of existing data, information and knowledge through a rigorous data quality objective process.

- Development of focused characterisation plans that will ensure that sufficient additional data are collected throughout decommissioning and demolition in order to allow decision making on the level of remediation required.

- Implementation of the characterisation plans to adequately define the extent of contamination.

Characterisation plans, detailing data quality objectives and how they will be fulfilled, will be developed for each characterisation campaign.

Remediation

Remediation will seek to reduce contamination on and emanating from the site in order to allow the “no danger” criterion to be met at the FEP. It is envisaged that this will be best achieved through “source removal”, i.e. the excavation and removal of contaminated soil and floor slabs.

An alternative approach of “breaking pathways” through the use of restoration cover may be appropriate in some areas and monitored natural attenuation may be appropriate for some non-radioactive contamination. A “remediation toolkit” is being developed as part of the ERPP to allow consideration of a range of options at a tactical level.

Remediation is currently planned to be undertaken on a zone-by-zone basis and each zone will consist of the following steps:

- Remove contaminated floor slabs and other contamination sources not removed during the demolition process and which do not satisfy the remediation targets. This may simply involve the removal of “hot spots” of contamination.

- Excavate soils that do not satisfy the remediation targets, or cover in a restoration layer in order to break pathways.

- Segregate soils and manage either as hazardous waste, or package as DLLW, LLW or HAW as appropriate.

- Collect verification samples in order to demonstrate that the “no danger” criterion has been satisfied.

The Client Specification requires there to be no residual contamination defined as radioactive waste remaining in the ground on site at IES. Where radioactive material above

the level defined as Out of Scope (OoS) in RSA 93 does remain, the Client Specification assumed that the SWESC could demonstrate that this would satisfy the applicable dose constraints and risk criteria and therefore not require authorisation. Dialogue with SEPA has, however, confirmed that buried infrastructure exhibiting contamination that is above OoS levels would be regarded as radioactive waste and thus requires an RSA 93 authorisation.
Gaining an authorisation for buried infrastructure classified as radioactive waste (i.e., radioactive material above OoS levels) would require additional modelling and documentation than anticipated for the SWESC. Remediation targets for contamination classified in this way would likely be higher than those derived to satisfy the NIA 65 “no danger” criterion because of different assumptions regarding intrusion. ONR’s interpretation of this criterion with respect to authorised disposals of radioactive waste is currently under review.

Overall, higher remediation targets would likely decrease the amount of remediation required and the volume of wastes generated, but would increase the effort required in developing environmental safety cases and also the risk that further remediation might be required before the site can be de-regulated at the FEP. Such changes are being considered as part of the optimisation process.

There is an assumption within the contract that removal of contaminated bedrock is not required to demonstrate compliance with the IES requirements. This is consistent with the lower exposure risk from bedrock relative to near-surface soils. It is also assumed within the planned scope of the SWESC that there will be a need to demonstrate that any contaminated rock left in situ does indeed satisfy these requirements.

It is anticipated that monitored natural attenuation of groundwater contamination will be appropriate in most instances, although enhanced natural attenuation, e.g. encouraging bacterial breakdown of contaminants, could be adopted if necessary.

Verification

Following remediation, further sampling will be required in order to demonstrate compliance with IES requirements. This verification stage will be used to:

- Demonstrate that no further source term removal is required
- Facilitate Zone Closure
- Underpin the SWESC for the IES
- Support development of a long term management plan for the period of institutional control
- Provide technical underpinning for future RSA revocation and nuclear site de-licensing.

Verification sampling and analysis may be in part done through in-field measurements. The remediation targets too low to be practically demonstrated in this manner will require onsite and offsite analysis. Early planning to ensure that facilities with the appropriate capabilities and availability will need to be identified and resourced. The compressed work programme will also increase the pressure on lab availability and turnaround.

Restoration

Restoration will seek to leave the site in a sustainable condition for potential re-use. This will involve capping, landscaping and re-vegetation to designs established during the early strategy definition element of the programme. Engineered caps will be constructed where necessary to ensure that remediated areas satisfy the IES requirements. The longer term drainage plans will also be finalised and implemented.

Although originally envisaged to be completed on a zone-by-zone basis following remediation, site restoration is likely to occur as a single pass across the whole site. The scope of the zone closure reports will require account for the implementation of the restoration plans. Compliance of zones with the IES requirements can nevertheless be demonstrated prior to final restoration activities.

Restoration will take place towards the end of the programme leading to the IES. It is important that initial plans for restoration and landscaping are made early in the programme so that requirements can be identified and incorporated into other aspects of the programme. Development of a landscape master plan has commenced. This work will inform the planning application and provide the basis for developing a more detailed restoration design. Engagement with key NDA and site stakeholders, including Highland Council, Scottish Natural Heritage and Dounreay Stakeholder Group, will be undertaken during the development of the designs and the final designs for the restored site will require agreement from Highland Council.

Trials and scoping assessments relating to restoration and landscape design have been initiated. Vegetation trials will inform the landscaping design and ultimately help ensure that long-term sustainable vegetation is established. The trials are assessing combinations of different grades and types of material and also different seed mixes. Scoping assessment of the quantity of restoration material required however indicates that there may be a short-fall of material from the site and that creative landscaping may be required in order to minimise the import of material.

Optimisation

The process of optimisation is an integral, ongoing component of the closure and restoration programme. At all stages, radiological risk will be reduced as low as reasonably achievable, taking into account cost, environmental and societal factors. The greatest reductions in risk are associated with the decommissioning and demolition stages. Risk reduction, and the consequent scope for further optimisation, will be much more limited in the remediation and restoration stages. Nevertheless, optimisation will continue, both through periodic review of the overall strategy and timescales and through review of zone-by-zone remediation activities.

The End State for the Dounreay site was originally laid out in the Dounreay Site Restoration Plan (DSRP). This vision for the End State was subsequently refined and developed by means of a Best Practicable Environmental Option (BPEO) study. This study followed a structured and transparent process, which incorporated stakeholder input in order to identify the preferred option(s) for the End State [15].

The BPEO study and associated consultation identified a series of options that would be acceptable End States for the site. One of the options (Option 4) was identified as being the best supported. This option was geared towards clearing and de-licensing the cleaner areas of site on an early timescale. The remaining part of the site would contain waste and fuel stores, which would be emptied by 2076, and areas with higher levels of residual

contamination, which would be managed in situ through natural attenuation and radioactive decay.

Since the BPEO study was published there have been various developments that influence the End State. The main change compared to the BPEO study arising from the contract definition is that
de-licensing of areas of the site at IES is no longer required and de-licensing of the whole site is currently scheduled to be undertaken at the FEP. This change has arisen primarily through recognition that the regulatory strategy for site de-licensing is still developing and is not mature enough to allow contract deliverables to be based on its outcome. This change can be viewed as an optimisation of the BPEO strategy taking account of societal factors.

DSRL is currently embarking on a review of Site End State options to determine what might be the preferred option should the options be unconstrained by current regulatory guidance and policy positions. One example of a potential change is the treatment of buried infrastructure. If these are contaminated to levels above those considered as OoS under RSA 93 they would be regarded as radioactive waste and therefore require a RSA 93 Authorisation for disposal if left in situ. Waste disposals that satisfy the requirements for such an authorisation may not satisfy the current interpretation of the NIA 65 “no danger” criterion. Furthermore, the NDA contract requires that any contamination remaining in the ground at IES is managed as radioactive material, not as a waste.

A re-consideration of these constraints, alongside the development of regulatory guidance and discussion with other stakeholders, could introduce the opportunity to manage contaminated sub-surface structures as in situ disposals, which would likely have significant implications in term of remedial effort and volumes of waste to managed ex-situ. The scale of the possible changes to waste volumes has yet to be ascertained although an initial list of potential sources is being developed. Dialogue with decommissioning projects will help to develop a better understanding and allow an estimation of the volumes concerned.

DEMONSTRATING SITE END STATES

Zone Closure Compliance Documents

The zone-by-zone approach to the characterisation and remediation of the site described in the ERPP will be documented through reports on each study area within a zone that demonstrate the areas of land, groundwater, services and structures are compliant with the contractual requirements for IES, such that the zone can be closed. Zone closure is required to:

- Demonstrate that no further source term removal is required in order to achieve IES compliance
- Demonstrate that all contract requirements associated with closure of a zone have been completed
- Underpin the SWESC for IES
- Support development of long term management plan for the period of institutional control
- Provide technical underpinning for future RSA revocation and nuclear site de-licensing.

If compliance with the IES requirements relies on credit being taken for natural attenuation of residual contaminants, the Zone Closure Compliance Report (ZCCR) must describe the associated assumptions, making reference to the underpinning assessment and justification for decisions (e.g. ALARP/BPM, Remedial Action Plan). The ZCCR must identify any monitoring requirements in order to verify that the system is responding as expected and identify actions to be taken in the event of the system not responding as expected.

The ZCCR must state when the zone could achieve FES and what the additional radiological risk above background associated with the zone is at the FEP. The report should document that the overall risk is as low as reasonably practicable, given the likelihood of further natural attenuation processes. If the zone does not meet the "no danger" criterion then the ZCCR must identify forward actions to be implemented to make the zone compliant with the end state criterion.

Sitewide Environmental Safety Case

The SWESC will set out the claims for environmental safety at the IEP and beyond. It was originally intended for regulatory submission and approval but it is now recognised that there is currently no regulatory focus at IEP although the emerging SEPA revocation guidance may lead to some requirements being set. In any event, the SWESC will be developed in consultation with the regulators, with a process by agreement used to approve transfer of the site from a period of remediation and restoration to a period of institutional control and monitoring beyond the IEP. Early agreement with the regulators on the format and content of the SWESC will ensure that the appropriate evidence is collated as the remediation and restoration work progresses.

The SWESC will support the demonstration that DSRL has fulfilled the contractual requirements for the IES. The overall safety arguments for the IES will be defined early in the process, with the SWESC thereafter developed by means of the growing body of evidence that is produced as the programme progresses. A key element of the SWESC will be the ZCCRs, supported by documentation of site-wide restoration and closure processes as required. The SWESC will state when the site could achieve FES and the additional radiological risk associated with the site, together with the conceptual model, judgements and assumptions used to anticipate the evolution of the site. Any forward actions to be implemented to make the zone compliant with the end state criterion will be documented.

The SWESC will provide technical underpinning for future nuclear site de-licensing and RSA revocation and will be developed in due course into a Site Closure Safety Case for de-licensing and a SWESC for RSA 93 revocation.

Long-Term Management Plan Development

With respect to the remediation and restoration programme, achieving the IES will mark the end of the active programme. Prior to IES being achieved, a long-term management plan will need to be developed by Dounreay on behalf of NDA for the management of the site during the period of institutional control between the IEP and FEP.

The period of institutional control is also the period when continuing decay and attenuation of contaminants left in-situ will lower concentrations to the point where the requirements for the FES can be met. An extension to the characterisation programme carried out during the verification phase of remediation will be required to ensure that the evolution of site conditions is as expected.

CONCLUSION

The completion of the decommissioning to site restoration following this ESS will propel the Dounreay site to achieve the IES. Using the tool-kit provided by the ERPP will help to ensure that the “road map” to environmental restoration follows good technical and management practice underpinned by compliance with the regulatory regimes.

Achieving the IES marks the end of the active programme. The site will remain under regulatory control during the institutional control period. The post management plan will detail a programme of routine monitoring to demonstrate compliance with limitations and conditions of the RSA 93 authorisation and the nuclear site licence that apply during the period of institutional control.

The institutional control period is expected to be of up to 300 years and it is not realistic to include details of specific sampling and analysis protocols for this length of time in the management plan. The long-term plan must therefore include provision for its own revision and continuation, with appropriate mechanisms for retaining information and transferring knowledge to future generations.

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