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Implementing ONR's strategy for licensing a future Geological Disposal Facility

Review of ONR's regulatory guidance for Geological Disposal

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EXECUTIVE SUMMARY

When considering the high hazard inventory of a Geological Disposal Facility (GDF) and in line with Government policy, ONR believes that a GDF should be licensed subject to the requirements of the Nuclear Installations Act 1965 during the assessment, construction and operational phases.

Many nuclear nations are pursuing geological disposal as a means of safely and securely disposing of higher activity radioactive waste and spent fuel. Significant progress with geological disposal has been made in many countries, including Sweden, Finland and France. ONR has sought to utilise its existing Information Exchange Agreements with international regulators to capture relevant regulatory intelligence while developing its approach to regulating a future GDF in the UK.

Guidance on ONR's expectations with respect to granting a new nuclear site licence is provided to prospective licensees in *Licensing Nuclear Installations*. ONR has undertaken a separate review of its licensing guidance and recommended inclusion of a GDF specific Annex within *Licensing Nuclear Installations*.

A GDF represents a new type of facility not previously regulated in the UK. As such, ONR has recognised the need to review its regulatory guidance with respect to their application to a future GDF.

This review considered common safety themes identified from international standards and guidance specific to radioactive waste disposal facilities, including IAEA, WENRA and international nuclear safety regulators, comparing these to the guidance provided in ONR's , Safety Assessment Principles and Technical Assessment Guides.

The review concluded that the Safety Assessment Principles are appropriate for application to a GDF. However, the review has identified a number of technical areas where guidance on ONR's expectations specific to a GDF is required.

It is recommended that ONR develop a new Technical Assessment Guide on Geological Disposal to provide supplementary, detailed technical guidance to inspectors, on the application of the Safety Assessment Principles to a GDF.

In addition to providing guidance on application of the Safety Assessment Principles, the new Technical Assessment Guide will identify relevant good practice internationally and from associated industries, provide reference to ONR's existing suite of guidance, and become a single reference for ONR's expectations specific to a GDF. During development of the new guidance, it is recommended ONR further consider the content of its current Technical Assessment Guides to identify any additional areas requiring specific guidance.

In developing the new guidance, ONR will continue to engage other regulatory bodies, both within the UK and internationally, to gather intelligence from related industries and more advanced GDF programmes around the world, incorporating this learning into the UK framework for regulating geological disposal.

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LIST OF ABBREVIATIONS

ALARP	As low as reasonably practicable
EA	Environment Agency
GDF	Geological Disposal Facility
GRA	Guidance on Requirements for Authorisation
HAW	Higher Activity Radioactive Waste
HID	Hazardous Installations Directorate (HSE)
HLW	High Level Waste
HSE	Health & Safety Executive
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
LC	Licence Condition
LLW	Low Level Waste
LLWR	Low Level Waste Repository
LMfS	Leadership and Management for Safety
LNI	Licensing Nuclear Installations
NEA	Nuclear Energy Agency (OECD)
NRW	Natural Resources Wales
OECD	Organisation for Economic Co-operation and Development
ONR	Office for Nuclear Regulation
RP	Radiological Protection
RWM	Radioactive Waste Management Ltd
SAP	Safety Assessment Principle(s) (ONR)
SMP	Safety Management Prospectus
SRL	Safety Reference Level (WENRA)
SyAP	Security Assessment Principle(s) (ONR)
TAG	Technical Assessment Guide(s) (ONR)
TIG	Technical Inspection Guide(s) (ONR)
WENRA	Western European Nuclear Regulators Association

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1 BACKGROUND

1. A Geological Disposal Facility (GDF) will contain the highest radioactive inventory in the UK, including: vitrified high level waste (HLW), intermediate level waste (ILW), a significant proportion of the spent fuel currently stored at Sellafield, and all spent fuel from currently planned new nuclear power stations; collectively termed higher activity radioactive waste (HAW).
2. The radioactive inventory will be in a passively safe form, and packaged in highly engineered robust containers that will reduce to the workforce, and the public, so far as is reasonably practicable. However, there will be activities, both above and underground, in the operational phase of the GDF; including: surface interim storage of waste packages, unloading waste packages from transport overpacks, package handling and disposal; which will need to be performed safely.
3. Therefore, when considering the high hazard inventory of a GDF, the requirements of relevant EC Directives and international standards and relevant good practice, ONR considers that a future GDF should be subject to the requirements of the Nuclear Installations Act 1965 during its design, construction and operation, and regulated for nuclear safety purposes by ONR [1]. This is in line with Government expectations as outlined in the 2014 White Paper, Implementing Geological Disposal [2]. Disposal is not currently a prescribed activity under the Nuclear Installations Regulations 1971 (NIR71) and as such, ONR has not previously licensed a facility for the purposes of disposal.¹
4. ONR has recognised that regulating a future Geological disposal Facility (GDF) represents a new technical challenge. ONR's assessment guidance has never been applied to this type of facility before and there will be aspects to the design, construction and operation of a GDF that have not previously been encountered in the UK nuclear industry.
5. There is however, knowledge and experience held internationally that provides relevant good practice in the context of geological disposal. To ensure that such learning is incorporated, ONR has conducted a gap analysis to compare the expectations set out in international guidance for geological disposal against its own regulatory guidance.

2 SCOPE FOR ASSESSMENT OF ONR REGULATORY GUIDANCE ON GEOLOGICAL DISPOSAL

6. ONR has established its Safety Assessment Principles (SAPs) [3] which apply to assessments of safety at existing or proposed nuclear facilities, usually through assessment of safety cases in support of regulatory decisions. The primary purpose of the SAPs is to provide ONR inspectors with a framework for making consistent regulatory judgements on the safety of activities at nuclear licensed sites, and may also provide guidance to designers and duty-holders on the appropriate content of safety cases clarifying our expectations in this regard..
7. The principles presented in the SAPs are supported by a suite of Technical Assessment Guides (TAGs) [4] The TAGs provide guidance to ONR inspectors on the interpretation and application of the SAPs in particular technical areas. Although it is not their prime purpose,, they also provide information to licensees regarding ONR's

¹ Government is taking forward work to amend the Nuclear Installations Regulations 1971 to include a geological disposal facility on the list of prescribed installations which require a nuclear site licence under the Nuclear Installations Act 1965.

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expectations of the nature and content of relevant technical elements of licensees' safety cases.

8. The ONR review has not considered each of the TAGs in detail to assess the applicability of the regulatory advice to geological disposal as this was considered disproportionate at this time. During ONR's regulatory review of the generic Disposal System Safety Case for a future GDF, ONR's specialist assessment community will provide advice on specific areas that require development of further guidance. Notwithstanding this, several technical topics have already been identified, at a high level, for development with ONR's guidance for geological disposal, including regulatory engagements to develop internal knowledge and capability.

3 GAP ANALYSIS OF ONR GUIDANCE AGAINST INTERNATIONAL GUIDANCE

9. There is considerable guidance on geological disposal published internationally, by various organisations involved in delivery of such facilities; including international fora, waste management organisations, and regulators. Much of this guidance is complimentary and overlapping.
10. In 2012 a European Commission funded project called *Sustainable network of Independent Technical Expertise for Radioactive Waste Disposal (SITEX)* was initiated. The project's objective was to "establish the conditions to build a network of technical expertise independently from the operators to support the regulatory bodies in its activities of regulating, authorizing and verifying the compliance of geological repositories for radioactive waste."
11. One of the SITEX deliverables was to produce an overview of the existing technical guides relevant to geological disposal, and provide advice on necessary further development [5]. This review is referred to as the SITEX report hereafter.
12. The SITEX report collated the available guidance from international bodies and safety regulators, specific to geological disposal, and developed 35 common key safety topics, and a further 17 sub-topics. SITEX focused on safety and did not consider security or Safeguards requirements in its review.
13. ONR compared each safety topic to its own guidance and simultaneously evaluate against WENRA Safety Reference Levels (SRLs), IAEA Requirements, ICRP Recommendations, Articles of European Directives, and national regulatory guidance.
14. ONR considers the SITEX report to be a competent overview of the available guidance on safety of and at a GDF. It was considered most efficient and effective to utilise the common safety topics identified in the SITEX Report as reference for comparison to ONR's guidance, owing to the overlap amongst the large volume of guidance.
15. The ONR review [6, 7] ranked each of the safety topics and sub-topics defined by the SITEX report in one of three categories:
 - A – topic relevant and covered in ONR guidance
 - B – topic not relevant to ONR (ie matter for the relevant environment agency)
 - C – topic relevant but not covered in ONR guidance
16. Topics ranked as a 'C' are key areas where the review recommended development of ONR guidance. The review identified 7 safety topics/sub-topics which are ranked as 'C' – these are discussed below, with recommendations for provision of additional ONR guidance where necessary.

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17. Even where a topic is ranked as 'A', the review provided recommendations for development of additional guidance where relevant. These recommendations will be considered when developing additional guidance to address the topics ranked as 'C'.

3.1 REVERSIBILITY AND RETRIEVABILITY

18. The terms 'reversibility' and 'retrievability' are used to mean subtly different operations in different countries [8]. In the UK, retrievability is a matter of Government policy. The 2014 White Paper [2] states that "during the operational stage of a GDF (that is, when it is accepting and placing waste), waste that has been placed in a GDF could be retrieved if there was a compelling reason to do so."
19. The White Paper goes on to state that "Retrieving placed waste would tend to become more difficult with time, particularly after the end of its operational stage (that is, once a GDF has been closed permanently)."
20. The White Paper does not rule out retrievability, nor does it place any specific requirements on the future licensee regarding retrievability, as is the case in France where retrievability of waste must be possible for period of time specified in Law [9].
21. The ONR review [7] concluded that at present, ONR has no defined position regarding the option to retrieve waste once emplaced in a GDF, noting that this topic has been considered extensively internationally. There are obvious implications for the design of a GDF if there are requirements for retrievability, which should receive consideration early to ensure that safety, both operational and long-term post-closure, is not compromised.
22. ONR is of the opinion that the purpose of a GDF is for the permanent disposal of higher activity waste, and not storage pending retrieval. Additionally, once waste has been emplaced, ONR would consider that installation of the backfill around the packages would be the safest configuration for the waste disposed. However, ONR recognises that there may be operational advantages in delaying installation of the backfill (eg package monitoring), but such decisions are for the future licensee to take and provide adequate justification for.
23. I recommend ONR provide guidance on consideration of the safety implications around retrievability, providing clarity regarding ONR's expectations for justification of decisions. This guidance should set out definitions for each of the terms used to promote clarity and consistency, taking due account of the Nuclear Energy Agency (NEA) Radioactive Waste Management Committee (RWMC) flyer [10].

3.2 CONCURRENT UNDERGROUND ACTIVITIES

24. Operational needs are likely to require construction of new disposal galleries running concurrently with disposal operations in galleries already constructed. The two types of activity represent different hazards and will require different safety protections to be in place.
25. IAEA SSG-14 [11] states that during construction of the disposal facility, consideration should be given to concurrent excavation and waste emplacement activities, and that "construction should reflect a combination of the best radiological, industrial and civil engineering safety practices."
26. The ONR review [7] concluded that this topic should be developed with ONR's guidance to provide specific guidance on the complexities of managing such activities underground.

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27. Current operators of nuclear licensed sites need to adequately control risks from hazards associated with construction of new facilities, with particular attention given to those proximal to existing facilities with nuclear safety significance.
28. I do not consider that additional safety assessment principles are required on this topic since the requirement for a licensee to control impacts from construction activities upon existing facilities already exists within the SAPs:
- ELO.1 – Engineering principles: Layout – Access
 - ECE.25 – Engineering principles: Civil Engineering: Design – Provision for construction
29. Furthermore, provisions exist under several Licence Conditions (LC) [12] for ONR to exert regulatory control:
- LC 19 – Construction or installation of new plant
 - LC 20 – Modification to design of plant under construction
 - LC 21 – Commissioning
 - LC 22 – Modification or experiment on existing plant
30. In addition to the guidance available relevant TAGs, guidance is also provided in the relevant Technical Inspection Guides (TIGs) [13] on ONR's expectations regarding licensee arrangements for the above LCs.
31. However, I conclude that additional guidance is required for GDF construction and operation, owing to the additional hazard of undertaking these operations underground, and the potential use of excavation techniques such as blasting.
32. I recommend ONR develop guidance on expectations for consideration of managing concurrent excavation/construction and waste emplacement activities, and the impact this could have on the design and operation of the facility.

3.3 SAFETY POLICY AND STRATEGY

33. The ONR review [8] concluded that guidance on the safety strategy, specific to a GDF, is not adequately provided at present. However, the ONR review focussed solely on the strict IAEA definition, failing to take account of ONR's expectations for a Safety Management Prospectus (SMP).
34. IAEA SSG-23 [11] defines the term 'safety strategy' in the context of a GDF, after an earlier report from the NEA [14], as:
- a "high level integrated approach adopted for achieving safe disposal of radioactive waste...[comprising] an overall management strategy for the various activities required in planning, operation and closure of a disposal facility, including siting and design, development of the safety case, safety assessment, site characterization, waste form characterization, and research and development."*
35. Guidance to prospective licensees regarding ONR's expectations for successful application for a nuclear site licence is contained within Licensing Nuclear Installations (LNI) [15]. As part of the licence application, the prospective licensee must submit to ONR a SMP. ONR's TAG on the Function and Content of Safety Management Prospectus [4] states that the SMP is a strategic document that should provide a narrative thread covering the following aspects:
- the type of activities carried out on the licensed site;

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- the role of directors, managers and leaders in focussing the organisation on achieving and sustaining high standards of safety;
 - the arrangements for ensuring and assuring nuclear safety;
 - how the organisation will ensure that it has adequate structures and resources to ensure the safe operation of the licensed site;
 - the decision making processes to ensure that safety is given a high priority and is evident in all decision making;
 - how the management system will bring together in a coherent manner all the requirements for managing the licensee organisation; and
 - how lessons will be learned from internal and external sources to continually improve leadership, organisational capability, safety decision making and safety performance.
36. I therefore consider that guidance on ONR's expectations regarding the elements of the "safety strategy", as defined by the NEA and IAEA, are adequately provided in the existing guidance, at a general level applicable to all licensed sites.
37. Notwithstanding this, I recommend ONR consider if additional guidance on the specific expectations regarding safety strategy for a GDF, including application of the multi-barrier principle in the disposal concept to provide defence in depth for safety of waste disposal activities, is appropriate.

3.4 EMERGENCY PREPAREDNESS AND RESPONSE

38. The ONR review [7] concluded that ONR's current guidance sufficiently transposes the expectations for emergency preparedness and response provided in the relevant WENRA SRLs and IAEA standards and guidance.
39. However, the ONR review [7] also concluded that this guidance was not specific to the case of a GDF and the risks created from operating underground. The review therefore recommended that ONR explore this topic further to develop knowledge of relevant good practice from related industries.
40. A GDF will be a low risk site and Radioactive Waste Management Ltd (RWM – the prospective licensee) do not anticipate that an off-site emergency plan will be required as a 'radiation emergency' is not possible for the current predicted inventory. The current HIRE report asserts that off-site consequences from a GDF are "extremely unlikely" to exceed 5 mSv [16].
41. Notwithstanding the possibility a GDF will not require an off-site plan, I recommend ONR consider if further guidance on expectations for emergency preparedness and response, focussing on underground emergencies and incorporating relevant good practice from international GDF projects and related industries, is required.

3.5 MONITORING

42. Monitoring in the context of a GDF is most usually associated with post-closure performance. However, there are some significant operational safety related applications for monitoring.
43. The ONR review [7] concluded that most of the international guidance on monitoring was connected with post-closure, and hence not a matter for ONR, except for Requirement 10 in IAEA SSR-5 [11]: *"an appropriate level of surveillance and control shall be applied to protect and preserve the passive safety features, to the extent that this is necessary, so that they can fulfil the functions that they are assigned in the safety case for safety after closure."*

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44. This requirement points to the impact that continuing operations may have upon waste that has already been disposed. It is not just the waste that may need to be monitored, but potentially also the facility itself. For example, the plastic nature of evaporite deposits means that the excavated disposal galleries self-seal around the waste (a benefit of a salt host rock), but this introduces the potential for roof collapse, as observed at the WIPP facility [17].
45. Additionally, monitoring may be required to satisfy Safeguards obligations for waste containing special nuclear materials to be disposed in a GDF.
46. I recommend ONR provide guidance on the need for, and expectations of, monitoring at a GDF, covering operational safety and Safeguards.

3.6 SAFETY CASE: ASSESSMENT OF THE POSSIBLE RADIATION RISKS

47. IAEA define “possible radiation risks” in GSR Part 4 [11] as *“the maximum possible radiological consequences that could occur when radioactive material is released from the facility or in the activity, with no credit being taken for the safety systems or protective measures in place to prevent this.”*
48. The ONR review [7] did not consider that current ONR guidance adequately transposes the concept of “possible radiation risks”, especially in the context of a GDF.
49. Design Basis Analysis (DBA) is the robust demonstration of the fault tolerance of the facility and the effectiveness of the safety measures put in place to protect the plant from, or mitigate the consequences of, fault conditions.
50. In the approach advocated in the SAPs, faults are selected for DBA on the basis of their initiating frequency and their potential unmitigated radiological consequences. The selection by initiating fault frequency is to ensure that application of DBA is proportionately targeted to those fault sequences which contribute significantly to the overall plant risks.
51. By comparing the unmitigated radiological consequences of a fault sequence to the residual consequences assuming the applied safety measures operate successfully, enables determination of the success of those safety measures to adequately reduce doses ALARP.
52. Severe Accident Analysis (SAA) takes this a step further, considering the degraded plant state as its starting point and identifying what further plant, equipment and human action is required beyond those identified in the DBA as being reasonably practicable.
53. In consultation with a Fault Studies Specialist, I consider that to adequately meet ONR’s expectations regarding fault analysis, a duty holder would have to consider the “possible radiation risks”, although this may not be explicitly stated in ONR’s guidance.
54. I conclude that no additional guidance is required regarding “possible radiation risks” at the principle level. However, I recommend that ONR consider its expectations in relation to the specific case of a GDF through consultation with the Fault Studies specialism.

3.7 HANDLING OF UNCERTAINTIES IN THE SAFETY CASE

55. SAP SC.5 states ONR’s expectation that *“safety cases should identify areas of optimism and uncertainty, together with their significance, in addition to strengths and any claimed conservatism.”* Notwithstanding this, the ONR review [7] concluded

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guidance on handling of uncertainties with respect to geological disposal should be developed further.

56. I consider that the guidance in the SAPs supporting SC.5 is sufficient for the purposes of explaining ONR's expectations regarding the handling of uncertainty in safety cases. Consequently, I do not consider that any further guidance regarding handling of uncertainties is required for the specific case of a GDF.

3.8 ADDITIONAL TOPICS IDENTIFIED BY ONR REVIEW

57. A number of other topics were identified in the ONR review [7] that are considered to be areas that ONR should consider in developing its guidance in relation to geological disposal, but were not specifically captured as Safety Topics under the SITEX report. These topics are discussed in the following sections.

3.8.1 HUMAN INTRUSION

58. The risk of human intrusion has been identified as one pathway to bypass the multiple barriers of the GDF system and result in potential dose uptake by future human populations.
59. This topic is usually considered in the context of post-closure safety of a GDF and protection of future populations from the hazard posed by the waste disposed of to the GDF. This aspect is not relevant to the vires of ONR.
60. Whilst there are implications from human intrusion during the operational phase of the GDF which are relevant to ONR's vires, particularly relating to security, these are unlikely to be as a result of inadvertent intrusion. It is anticipated that institutional controls would prevent activities in the vicinity of the GDF that could inadvertently undermine the safety case and/or pose a risk to the public.
61. I recommend ONR consider developing guidance on prevention of human intrusion into the facility during the construction and operational phases, with a focus on the security aspects.

3.8.2 IMPACT OF LONG OPERATIONAL TIMESCALES

62. A GDF is anticipated to take on the order of 20 years to construct and have an operational lifetime up to 150 years prior to closure of the facility. This is an unprecedented timescale for operating a nuclear facility and presents many challenges to the duty holder, for instance: record keeping and knowledge management, ageing management of the facility, and organisational resilience.
63. ONR already has guidance on retention of records and asset management [4] which strengthen ONR's expectations in the SAPs regarding these topics (eg EAD.1-5, ENM.4, RW.7, DC.1, DC.6).
64. I recommend ONR consider its current guidance and the applicability of its expectations for the duty holder regarding the impact of the extended timeframes of a GDF when compared to other nuclear facilities.

3.9 WENRA DISPOSAL SAFETY REFERENCE LEVEL BENCHMARKING

65. ONR has committed to transpose relevant WENRA SRLs into its SAPs and TAGs. A process of self-assessment followed by WENRA peer review to ascertain implementation of the Disposal SRLs [18] in the UK framework (including guidance

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provided by the EA) identified 4 SRLs relating to the vires of ONR where the UK is currently rated as non-compliant [19]:

- DI-30: If construction, operation, decommissioning or closure activities take place concurrently, the licensee shall perform the works so that they will not have an unacceptable effect on operational or post-closure safety.
- DI-31: The licensee shall ensure that any measures necessary for the purpose of accounting for and control of nuclear material shall not unacceptably affect operational and post-closure safety.
- DI-41: The licensee shall have a process for identifying any conflicting design requirements from different regulatory regimes, and seeking to resolve them.
- DI-69: Before starting decommissioning and closure, the licensee shall define the corresponding program so that it takes into account, as appropriate:
Programs for security and safeguards

66. ONR has committed to developing additional guidance to close the non-compliances as part of the current review for geological disposal.

4 SPECIALIST TOPIC AREAS REQUIRING CONSIDERATION FOR FURTHER TECHNICAL GUIDANCE

67. This section identifies, at a high level, technical topics requiring consideration for development of additional guidance specific to geological disposal. The topics identified are not meant to be an exhaustive list and it is expected further topics may be identified during ongoing regulatory interactions, including assessment of the generic Disposal System Safety Case for a future GDF.

68. Topics identified in this section are grouped by ONR technical specialism recommended to lead development of expectations and identification of relevant good practice.

4.1 MECHANICAL ENGINEERING

69. Ventilation systems for nuclear applications are primarily designed to provide containment of radioactive materials preventing contamination of people and plant. The ventilation system for a GDF will be required to provide this function (eg. in the event of a release of radioactivity) in addition to the more conventional application in mining environments, which is to provide a respirable atmosphere. Guidance is required on expectations in respect of both of these applications for the ventilation system(s) in a GDF.

70. The depth of the disposal galleries in a GDF is planned for between 200m and 1000m below ground, depending upon a suitable geological horizon. Transfer of the waste to the disposal galleries may be via a lift shaft system. Although such shafts are used in conventional mining applications, this would be novel to the nuclear industry and the hazard of the load to be transferred.

71. There is considerable knowledge and expertise relating to operational experience of nuclear lifting operations. However, the requirements of the lifting equipment, both mobile and fixed may be impacted by deployment underground. This should be explored further with appropriate guidance provided as necessary.

72. Expectations regarding the integrity of waste packages may require further guidance to be developed, given the potential for extended periods prior to backfilling or policy requirements for retrievability of waste packages. I recommend advice be sought from

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the Structural Integrity and Mechanical Engineering specialisms regarding the adequacy of current guidance.

4.2 CIVIL ENGINEERING & EXTERNAL HAZARDS

73. There is extensive experience regarding underground excavation and construction techniques from other industries, both in the UK and internationally. However, these are unlikely to have previously been deployed in the UK nuclear industry. ONR should therefore develop guidance on application of relevant good practice from related industries and expectations regarding nuclear safety.
74. For example: validation of the integrity of engineered vaults over extended periods for disposal of radioactive wastes; and the impact of underground construction techniques on the surrounding host rock giving rise to potential nuclear safety implications.

4.3 NUCLEAR LIABILITIES REGULATION

75. Waste package records are already recognised as an integral aspect of forming a disposable package. Given that a nuclear safety hazard may persist from disposed waste packages throughout the operational period. Licensees are currently required to retain relevant records for 30 years (LC6), although records of nuclear material disposed of on the site are not specifically referenced (LC25). Guidance should be provided on the expectations for record retention for waste packages once they have been disposed of in light of the extended operational lifetime of a GDF and the ongoing risk from disposed packages.
76. Guidance should be provided on the regulatory expectations regarding decisions on timing of backfilling of emplaced waste packages, and the necessary justifications to support those decisions.
77. Guidance should be provided on the topic of decommissioning of the underground facility and the necessary justifications to be provided to support decisions in this regard.
78. Decisions taken during the design of the GDF to provide benefit for post-closure safety may have a dis-benefit to operational safety, and vice-versa. Guidance should be provided, in conjunction with the relevant environment agency, to set out the regulatory expectations for justifying such decisions.

4.4 SECURITY

79. ONR has developed several technical assessment guides on its expectations regarding aspects of nuclear security, leading to development of its Security Assessment Principles (SyAPs) to deliver objective based security regulation.
80. Notwithstanding this, ONR should consider the potential security challenges specific to a GDF and provide appropriate guidance. For example, these may include protection of underground access points that may be located distant from the main site (eg secondary ventilation shaft).

4.5 SAFEGUARDS

81. Safeguarding of nuclear materials involves regular physical verification, and permanent disposal of such materials is at odds with those requirements. Approaches to and guidance on safeguarding requirements for disposal of nuclear materials is being developed internationally. The new TAG should provide appropriate reference to the

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international requirements to ensure the UK is aligned and continues to meet its obligations.

4.6 CONVENTIONAL FIRE SAFETY

82. International learning from experience of the underground fire at the Waste Isolation Pilot Plant, New Mexico, highlighted the requirement for effective management of materials and equipment to prevent favourable circumstances for a fire. An underground fire is a major hazard for a GDF, and as such, ONR should consider identification of relevant good practice specific to underground facilities.
83. One option considered by some GDF concepts is the use of electric vehicles to reduce the underground combustible inventory. ONR should consider identification of relevant good practice on use of vehicles in an underground facility.
84. The host geological environment may impact provision of fire detection and management systems owing to the complexities of installing and maintaining such systems in underground facilities. As such, guidance on regulatory expectations should be developed to ensure adequate fire safety is maintained underground, drawing upon relevant good practice from related industries.
85. Relevant good practice from the mining industry on expectations for provision of emergency escape equipment and refuge areas to be deployed in the underground facility should be identified.

5 REGULATORY INTERACTIONS RELATED TO GEOLOGICAL DISPOSAL

86. Besides reviewing the applicability of its regulatory guidance, ONR is engaged in developing its approach to regulating a future GDF through interactions with other key stakeholders. These interactions will be used by ONR to inform development of its guidance for future regulatory assessment and decision making; including regulatory research into operational safety, incorporation of operational experience from other regulators, and through scrutiny of the implementer – RWM.

5.1 REGULATORY RESEARCH INTO OPERATIONAL SAFETY AT A GDF

87. ONR engages with RWM regarding its research into geological disposal through the joint regulatory Pre-Application Advice and Scrutiny programme, monitoring its research strategy to ensure knowledge gaps are appropriately targeted and commissioned research delivers the required outputs.
88. Further, ONR has an ongoing regulatory research project focussed on Safety Implications of the Design, Construction and Operation of a Geological Disposal Facility [20]. This project intends to develop knowledge and capability to underpin regulatory decision making, with a focus on operational safety and industrialisation of geological disposal concepts.

5.2 ENGAGEMENT WITH OTHER REGULATORS

5.2.1 INTERNATIONAL ENGAGEMENT

89. Several countries have GDF programmes that are more developed than in the UK which affords ONR the opportunity to learn from the experience of its sister nuclear safety regulatory organisations in those countries regarding their approach to regulating geological disposal. ONR has identified Canada, Finland, France, and Sweden as priority opportunities for bilateral engagement on regulating geological disposal.

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90. In addition to bilateral engagements with other nuclear safety regulators, ONR should increase its involvement in international forums concerned with operational safety at GDF; expert working groups under the auspices of the IAEA and the NEA are engaged in developing regulatory expectations for safety cases for GDF. Involvement with such fora will enable ONR to capture relevant learning and inform development of its technical guidance.

5.2.2 THE ENVIRONMENT AGENCIES

91. The Environment Agency (EA) is the environmental regulator in England responsible for permitting disposal of radioactive waste and ensuring GDF post-closure safety. The EA has published guidance on its requirements for authorisation (GRA) for a GDF [21].
92. In developing new guidance, ONR should work with the EA, and other relevant agencies², to ensure consistency in matters where operational safety and environmental safety overlap, particularly when decisions to protect safety in one regard may have dis-benefits in the other. Our regulatory expectations should be complimentary to promote efficient and effective regulation of geological disposal.

5.2.3 THE MINES INSPECTORATE

93. The Mines Inspectorate is a unit within the Health & Safety Executive's (HSE) Hazardous Installations Directorate (HID) with responsibility for regulating safety in underground mines, including; coal and non-coal mines, tourist mines, and mines used for storage and waste disposal (non-nuclear).
94. Although a GDF is not considered a mine, and thus the Mines Regulations 2014 are unlikely to apply, there is nonetheless a wealth of knowledge and experience relating to underground activities that are relevant to the construction and operation of a GDF.
95. As such, ONR should develop its own capability through engagement with the Mines Inspectorate to enable development and assimilation of relevant good practice into the nuclear regulatory framework for application to a GDF.

5.3 PRE-APPLICATION ADVICE AND SCRUTINY OF RWM

96. RWM has entered into a voluntary agreement with ONR and the EA to provide pre-application advice and scrutiny of RWM's work. The purpose of the scrutiny programme is to provide advice to RWM to ensure that it appropriately takes account of regulatory expectations during development of the safety case and also as an organisation capable of holding the necessary licence and permits to operate a GDF.
97. Through this pre-licensing engagement with RWM, ONR is able to identify topics of regulatory significance and where necessary take appropriate action to develop its own capability, including through development of technical guidance. This learning will be incorporated into the development of the TAG, where appropriate.

² If a suitable site is identified in Wales, then the regulatory responsibility would fall to Natural Resources Wales (NRW). Similarly, if a site in Northern Ireland is selected, the relevant regulator would be the Northern Ireland Environment Agency (NIEA). Currently, Scottish Government policy is for near site, near surface disposal, not geological disposal. However, ONR should seek to ensure its expectations for geological disposal do not have an adverse impact on Scottish policy through appropriate consultation with the Scottish Environment Protection Agency (SEPA).

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6 CONCLUSIONS

98. I conclude that following review of ONR's guidance against available international standards and guidance for geological disposal, the Safety Assessment Principles are adequate for application to a GDF, and no additional principles are necessary.
99. I conclude that the ONR review has identified a number of topics for which additional guidance should be developed. The identified topics are specific to a GDF and should be provided at the level of the TAGs to support interpretation of the SAPs for a GDF.
100. During preparation of this guidance, ONR should consult the relevant Professional Leads with technical oversight of the identified topics to determine the most appropriate location for the additional guidance; either within a new TAG on Geological Disposal or as an annex to the relevant existing TAG.
101. Technical areas that are determined not to require further specific guidance to be developed should still be referenced from within the Geological Disposal TAG, with clear sign posting to the existing guidance. This will ensure that the TAG is comprehensive with respect to ONR expectations and will provide clarity to inspectors and interested stakeholders.

7 RECOMMENDATIONS

102. It is recommended ONR develop guidance on the topic of Geological Disposal in the form of a new Technical Assessment Guide, or as annexes to existing TAGs, as informed by consultation with the relevant ONR Professional Leads. This new guidance should include the topics identified in this report, providing reference to other relevant ONR guidance as appropriate to avoid unnecessary duplication of common expectations.
103. It is recommended the following topics should be considered for development of additional guidance on geological disposal:
 - safety implications around retrievability, providing clarity regarding ONR's expectations for justification of retrievability options;
 - managing concurrent excavation/construction and waste emplacement activities, and the impact this could have on the design and operation of the facility;
 - specific expectations regarding safety strategy for a GDF, including application of the multi-barrier principle in the disposal concept to provide defence in depth for safety of waste disposal activities;
 - emergency preparedness and response specific to a GDF, incorporating relevant good practice from international GDF projects and related industries;
 - monitoring at a GDF in the context of operational safety, and any other ONR purposes (eg Safeguards, Security);
 - prevention of human intrusion into the facility during the construction and operational phases, with a focus on the security aspects;
 - the impact of the extended operational timeframes of a GDF when compared to other nuclear facilities;
 - integration of conventional and nuclear ventilation systems for the underground facility;

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- safety implications from prompt versus delayed emplacement of backfilling materials;
 - integration of operational and post-closure safety requirements and the resolution of potential impacts to facility design; and
 - application of international Safeguards requirements to nuclear materials disposed to a GDF.
104. It is recommended development of the new TAG adequately transposes the WENRA Disposal SRLs identified as not currently addressed by ONR guidance, including concurrent activities, impact from monitoring activities, processes to resolve conflicts from different regulatory regimes and security and safeguards issues during decommissioning.
105. It is recommended the new Technical Assessment Guide also provide guidance on incorporation of relevant good practice from associated industries applicable to geological disposal, as identified through consultation with each of ONRs technical specialisms, to include:
- underground excavation techniques;
 - validation of underground civil structures, vaults and galleries;
 - underground fire prevention, detection and protection;
 - use of vehicles underground; and
 - emergency escape arrangements, including refuge areas and personnel rescue.
106. It is recommended ONR further consider the content of its existing suite of TAGs to ensure that regulatory expectations for current nuclear facilities are adequate for application to a GDF, providing additional guidance where necessary. focussing in particular on:
- Asset management and waste package integrity
 - Operational Records
 - Lifting operations, including waste package transfer from the surface
 - Decommissioning
 - Security
107. It is recommended ONR continue to engage with other regulatory bodies to ensure adequate capture of relevant experience and learning, and provide integrated regulatory advice where required.

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APPENDIX 1 – DRAFT SCOPE FOR TECHNICAL ASSESSMENT GUIDE ON GEOLOGICAL DISPOSAL

1 INTRODUCTION

This section introduces the SAPs and their purpose, and providing brief explanation that the SAPs are supported by a suite of guides to further assist ONR's inspectors in their technical assessment work in support of making regulatory judgements and decisions; highlighting that this TAG is one of those guides.

2 PURPOSE AND SCOPE

This section will state the purpose and scope of the TAG; to set out ONR's expectations for regulating a GDF, and to provide guidance to advise and inform ONR staff in the exercise of their regulatory judgment.

3 RELATIONSHIP TO LICENCE AND OTHER RELEVANT LEGISLATION

This section makes the link between the TAG and the legislation that provides the legal basis for regulation of a GDF. All licence conditions will apply to a GDF, however, licence conditions that require additional clarification for application to a GDF will be identified and explanation provided.

4 RELATIONSHIP TO SAPS, WENRA REFERENCE LEVELS AND IAEA SAFETY STANDARDS ADDRESSED

This section will state the principal SAPs and explain why the additional guidance is needed; state how the relevant IAEA Safety Standards have been addressed; and demonstrate how the relevant WENRA Disposal SRLs have been addressed.

5 ADVICE TO INSPECTORS

This section is to provide supplementary, detailed and topical guidance to inspectors, usually in support of the relevant SAPs (which are set at the principle level). The initial scope of the TAG is set out below as topic headings that have been identified for further development. These are not presented in any specific order and are not meant to form a complete and exhaustive list of the technical scope of the TAG. During development of the TAG, topics identified here may be determined as adequately covered by existing guidance and thus removed from the scope of the TAG.

- 5.1 Reversibility and retrievability of radioactive waste
- 5.2 Management of concurrent underground activities
- 5.3 Safety strategy for a GDF
- 5.4 Emergency preparedness and response for an underground nuclear emergency
- 5.5 Monitoring at a GDF for operational safety and safeguards purposes
- 5.6 Security challenges posed by a GDF
- 5.7 Records retention, especially for disposed waste packages
- 5.8 Asset management of an operational facility lifetime over 150 years
- 5.9 Management of conflicting design requirements for operational and post-closure safety

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- 5.10 Decommissioning considerations
- 5.11 Underground nuclear and non-nuclear ventilation systems
- 5.12 Package handling operations including package transfer lifts
- 5.13 Underground excavation techniques
- 5.14 Geotechnical validation of excavated vaults
- 5.15 Timing of backfilling
- 5.16 Safeguards verification for disposed nuclear materials
- 5.17 Underground fire prevention, detection and protection
- 5.18 Underground vehicles
- 5.19 Emergency escape provisions and refuge areas

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