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Review of LLW Repository Ltd's "Requirement 2" submission

Technical Review of Volume 2: Assessment of Options for Reducing Future Impacts
from the LLWR

NWAT/LLWR/09/002 [Sector Code]

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Introduction

1.1 Site history

- 1.1.1 The Low Level Waste Repository near Drigg, Cumbria (LLWR) is located six miles south of the Sellafield site in the northwest of England. Radioactive waste disposal began at the site in 1959 when the LLWR was managed by the United Kingdom Atomic Energy Authority (UKAEA). The LLWR site occupies around 100 hectares; waste disposal operations take place in the northern 40 hectares of the site. During the early period of disposal operations, solid low level radioactive waste (LLW) was tipped and buried in shallow, clay-lined trenches, a practice similar to that used now in the landfill industry. Between 1959 and 1995, approximately 800,000 m³ of waste was disposed in seven trenches. These trenches are now covered by an interim earth cap, which incorporates a plastic membrane to minimise water ingress.
- 1.1.2 In 1986 the House of Commons Environment Committee published a report on radioactive waste (House of Commons, 1986). In response to the report's recommendations, the LLWR operator at the time, British Nuclear Fuels plc (BNFL), made major changes to disposal operations. Since 1988, wastes have been disposed of in containers emplaced in an engineered concrete vault (Vault 8). Typically, the waste is put into steel drums which are then compacted into 'pucks'. These pucks are packed into freight containers that conform to published standards of the international standards organisation ISO. The wastes in full containers are encapsulated in cement grout before being placed in the vault. Vault 8 has a total capacity of 200,000 m³; at the time of writing it is nearly full. The current operator of the LLWR, LLW Repository Ltd, plans to build additional vaults to accept further waste, subject to receiving planning permission from Cumbria County Council.

1.2 Regulatory background

- 1.2.1 The Environment Agency of England and Wales (the Agency; also referred to as "we" and "us") is responsible for authorising disposal of radioactive waste under the amended Radioactive Substances Act 1993 (RSA 93). In accordance with government policy, we periodically review authorisations for the disposal of radioactive waste. When we review an authorisation, we consider a wide range of information, including our conclusions from reviews of the environmental safety cases (ESCs) produced by the operators of a disposal facility.
- 1.2.2 The Health and Safety Executive (HSE), through its Nuclear Installations Inspectorate (NII), regulates nuclear safety. It ensures that radioactive waste on nuclear licensed sites is managed, conditioned and stored safely. The NII also has regulatory responsibility for accident risk management.
- 1.2.3 In 1999, we started a review of the RSA 93 authorisation for the LLWR, which was then held by BNFL. At that time, however, BNFL had not updated the impact assessment carried out in the 1980s by the National Radiological Protection Board (NRPB, now part of the Health Protection Agency, HPA). Our review was therefore unable to assess the potential impact of the site from existing and future (predicted) disposals. Consequently, in January 2000 we changed (varied) the LLWR authorisation and required BNFL to provide information about the environmental safety of the LLWR during its operational lifetime (Operational Environmental Safety Case, OESC) and after its final closure (Post Closure Safety Case, PCSC). BNFL submitted these two ESCs in September 2002 (BNFL, 2002a and 2002b). Between 2002 and 2005 we carried out a detailed assessment of the safety

cases (Environment Agency, 2005a) which raised a number of criticisms, many of which were formally recorded in Issue Assessment Forms (IAFs)¹.

- 1.2.4 Following the review of the 2002 ESCs, we reviewed the RSA 93 authorisation and in May 2006 granted a new one (Environment Agency, 2006a) to the operator, which by that time had become known as British Nuclear Group Sellafield Limited (BNGSL). In addition to the ESCs submitted by BNFL in 2002, this authorisation review also took account of the legislation and guidance in effect at the time (RSA 93, and the UK environment agencies' Guidance on Requirements for Authorisation (the GRA), Environment Agency *et al.*, 1997). Our concerns regarding the safety cases presented in 2002 led us to authorise disposals only to Vault 8, and required the operator to deliver an updated ESC by May 2011.
- 1.2.5 The LLWR site is now owned by the Nuclear Decommissioning Authority (NDA) and is operated on behalf of the NDA by a Site Licence Company (SLC). The SLC was initially BNGSL, but the authorisation was transferred in 2007 to a new SLC, LLW Repository Ltd, with no major changes to the authorisation. This change in SLC paved the way for the NDA to open the operation of the site to competitive tender. In 2008 United Kingdom Nuclear Waste Management Ltd (UKNWM Ltd) was awarded a contract from the NDA to manage and operate the LLWR. Shares in the SLC were transferred to UKNWM Ltd on 1 April 2008 and the SLC continues to be known as LLW Repository Ltd.
- 1.2.6 LLW Repository Ltd is currently authorised to dispose of solid low-level radioactive waste in Vault 8 of the LLWR, and to discharge from the site gaseous and liquid effluents associated with the LLW disposal operations. LLW Repository Ltd has planning permission to construct Vault 9 at the site to store LLW, but does not have planning permission or authorisation to dispose of LLW to Vault 9.
- 1.2.7 In Schedule 9 of the current authorisation we set a number of legal requirements for the operator to carry out improvements or supply us with additional information by defined dates (e.g. reviews of best practice and establishing a research and development programme). This report relates to our review of LLW Repository Ltd's work to fulfil Schedule 9 Requirement 2 and their progress towards fulfilling Schedule 9 Requirement 6.
- 1.2.8 Requirement 2 states that the operator, by 1 May 2008, must "provide the Agency with a full report of a comprehensive review of national and international developments in best practice for minimising the impacts from all waste disposals on the site. This shall include a comprehensive review of options for reducing the peak risks from deposit of solid waste on the site, where those risks arise from potential site termination events (e.g. coastal erosion and glaciation) and potential future human action."
- 1.2.9 In discussions with LLW Repository Ltd we agreed that, in addition to the specifics of Requirement 2, their response would also aim, as far as possible, to address the wider expectations expressed in our 2006 Decision Document (Environment Agency, 2006a), to:²
- (a) demonstrate that best practice is being applied to keep the peak risks from the site as low as reasonably achievable (ALARA);
 - (b) substantiate a proposal for the radiological capacity of the site (the maximum amount of waste that could be disposed of while still maintaining the site's environmental safety).

¹ Issue Assessment Forms (IAFs) are detailed records of concerns raised as part of the Environment Agency's review of BNFL's 2002 environmental safety cases. In a systematic manner they record issues that we expect the operator of the LLWR to address prior to submission of the next fully updated ESC in 2011.

² In section 4.6 of the Decision Document (Environment Agency, 2006b) we stated that "we will not authorise LLW disposals to the proposed Vault 9, until ... BNGSL has provided us with adequate information to allow the radiological capacity of the site to be determined ... and we will undertake a full review on the radiological capacity of the site and publish our findings." Later in the same section we stated that "we will not allow BNGSL to construct the final cap over the existing Vault 8 and trench disposals until BNGSL has provided us with the outcome of a wide-ranging risk management study ... that demonstrates that future impacts will be As Low As Reasonably Achievable (ALARA)." The latter decision is clearly reflected in Requirement 2. We have interpreted the former decision also to be reflected in Requirement 2 as it comes from the same section of the Decision Document. We have confirmed to LLW Repository Ltd that this is the case and they have agreed to include their proposals on radiological capacity in their Requirement 2 submission.

- 1.2.10 Requirement 6 states that, by 1 May 2011, the operator must “update the Environmental Safety Case(s) for the site covering the period up to withdrawal of control and thereafter.” This update should address our criticisms of the 2002 ESCs and supporting programmes (Environment Agency, 2005a, 2005b, 2006b). It should also take account of developments since the 2002 ESCs were produced, such as evolution of operating practices, additional information about the site, the design of the repository and the waste inventory, changes in ownership, and developments in government policy (Defra, 2007) and regulatory guidance (Environment Agency *et al.*, 2008).
- 1.2.11 Since 2006, we have had regular dialogue with LLW Repository Ltd about progress towards meeting the Schedule 9 requirements. We expected the information in LLW Repository Ltd’s response to Requirement 2 would provide some indications of progress on the updating of the ESC, and so serve as a milestone for assessing progress towards the 2011 deadline for the submission of the ESC.

1.3 Objectives of our review

1.3.1 The main objectives of this review are to:

- (a) assess whether the information supplied by LLW Repository Ltd represents a satisfactory response to Requirement 2;
- (b) identify from the information supplied any immediate implications for the conditions of LLW Repository Ltd’s authorisation;
- (c) assess the information supplied against the new regulatory guidance (Environment Agency *et al.*, 2008³), and to provide additional guidance to LLW Repository Ltd on its programme to develop an ESC that appropriately addresses the requirements of the GRA;
- (d) identify any additional assessment that we might need to carry out, such as independent R&D, model development, conduct of independent calculations, or examination of further documents, so that we can effectively and efficiently assess the ESC when it is provided.

1.4 LLW Repository Ltd’s submission

1.4.1 On 1 May 2008, LLWR Repository Ltd delivered to us five volumes setting out its response to Requirement 2:

- i. Volume 1 (LLW Repository Ltd, 2008a) summarises the submission and directly addresses the issues raised in Requirement 2;
- ii. Volume 2 (LLW Repository Ltd, 2008b) summarises the “comprehensive review of options for reducing the peak risks from deposit of solid waste on the site”;
- iii. Volume 3 (LLW Repository Ltd, 2008c) summarises developments in characterising the inventory and near field processes;
- iv. Volume 4 (LLW Repository Ltd, 2008d) summarises developments in site understanding (including geology, hydrogeology and coastal evolution);
- v. Volume 5 (LLW Repository Ltd, 2008e) summarises updates (since the 2002 ESCs) to LLW Repository Ltd’s assessment of the future performance of the facility.

1.4.2 These five volumes refer to a large number of supporting documents that provide details of the analyses, assessments and evidence that underpin the arguments presented in the top level volumes. In our assessment of LLWR Repository Ltd’s submission we have also

³ A consultation draft of the GRA for near surface disposal was issued in May 2008 (Environment Agency *et al.*, 2008), and a final version (Environment Agency *et al.*, 2009) in February 2009. In conducting this review we had access to the consultation draft, and initial indications of modifications likely to be made in finalising the GRA for near surface disposal. The final version was published as we were finalising our documentation of this review, and so was not explicitly taken into account. However, we do not believe that any differences between the consultation draft and the final version would significantly alter any of our conclusions or recommendations.

reviewed the supporting documentation to the extent we considered necessary for us to establish the soundness of the submission.

1.5 Our review

1.5.1 Our review considers LLW Repository Ltd's submission primarily in relation to:

- (a) Schedule 9 Requirement 2;
- (b) the April 2008 consultation draft of the environment agencies' Guidance on Requirements for Authorisation for near surface disposal, as an indication of progress towards meeting Schedule 9 Requirement 6; and
- (c) the IAFs from the review groups participating in our review of the 2002 ESCs.

This report and our four other main review reports (Environment Agency, 2009a–d) present our findings in relation to Requirement 2, the GRA/Requirement 6, and any general or significant observations arising from our consideration of the IAFs. Our full review of the submission against the IAFs will be reported separately to LLW Repository Ltd as part of our continuing dialogue leading up to the delivery of the full ESC due in 2011.

1.5.2 We report here on our technical review of LLW Repository Ltd's response to the technical authorisation requirement we set out in the RSA 93 authorisation granted to the LLWR operator in 2006. This does not constitute a review of LLW Repository Ltd's authorisation, although it will be taken into account in the periodic review of the authorisation, which is due to be completed in early 2009. This review may also provide input into future periodic reviews.

1.5.3 We have aimed in our review to identify all significant issues arising from the Requirement 2 submission and supporting documents. Where we do not comment on a particular point in the submission or accompanying documentation, it is unlikely (based upon the information presented to us at this stage) that we would raise that point as an issue in the future (particularly in our review of the full ESC). However, this cannot be taken as an absolute guarantee; we reserve the right to revisit any issues that we think warrant attention at any time in the future.

1.5.4 Where we have made recommendations to LLW Repository Ltd in this and the four other main review reports, we have classified them to assist in the prioritisation of action:

- (a) **Category A**
Relatively major issues for which the appropriate course of action is not immediately obvious. For these issues, we expect LLW Repository Ltd to provide substantial additional information, evidence or analysis in the full ESC. We also expect LLW Repository Ltd to report to us on their progress between now and delivery of the ESC. Such reporting might, for example, include detailed plans of action, descriptions of proposed approaches, models or data, or results from interim or provisional analyses.
- (b) **Category B**
Relatively major issues for which it is fairly clear what needs to be done. For these issues, we expect LLW Repository Ltd to provide substantial additional information, evidence or analysis in the full ESC. We will keep these issues under a degree of review via the regular dialogue between ourselves and LLW Repository Ltd and we will provide further guidance if requested. However, we will not require LLW Repository Ltd to report formally on progress.
- (c) **Category C**
Issues for which LLW Repository Ltd will need to provide some additional information, evidence or analysis in the full ESC, and report some or all of this to us between now and delivery of the ESC. Generally, we estimate the effort needed to address Category C recommendations will be substantially less than for Category A.
- (d) **Category D**
Issues for which LLW Repository Ltd will need to provide some additional information, evidence or analysis in the full ESC, without the need for formal reports on progress.

Generally, we estimate the effort needed to address these points will be substantially less than for Category B.

Where our recommendations or other observations are not assigned to any of the above categories, we do not expect or require a specific response from LLW Repository Ltd. Nevertheless, LLW Repository Ltd may wish to consider these points as suggestions because they may, individually or collectively, affect our general confidence in the ESC or the ease with which we can review it. For example, individual typographical errors in reports may be considered trivial, but if persistent or present in large numbers, they could affect our confidence in the quality controls applied by LLW Repository Ltd.

- 1.5.5 We recognise that some of the issues raised in our review may be at least partly addressed in the updated and expanded Safety Case Approach document that LLW Repository Ltd produced at the end of 2008 (Baker *et al.*, 2008), but we have not included consideration of the Approach document in this review.
- 1.5.6 Our review mirrors the structure of LLW Repository's submission. Four separate technical review documents address Volumes 2–5 of the submission (and the supporting documentation), and an overarching summary review document provides specific comments on any aspects of Volume 1 not covered elsewhere and presents our overall assessment of the submission.
- 1.5.7 This technical review document addresses Volume 2: Assessment of Options for Reducing Future Impacts from the LLWR.

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1 Review of Volume 2 and key supporting documents

2.1 Approach and scope of the BPEO study

2.1.1 In the Introduction, LLW Repository Ltd state that:

“The objective of the assessment described in this Volume is to identify those options that should be adopted in order to best manage the future impacts from the facility. It addresses the management of solid waste disposed to the facility. It does not consider managing contamination that has migrated from the facility, for example in groundwater, or the management of contaminated land at the site.”

We consider that this statement of scope creates an artificial distinction – at what point in the future do “future impacts” start? Radiological impacts are a result of a continuous progression of radionuclides in the waste and existing contamination migrating off site.

2.1.2 The claim is made that “the site is considered to be safe now” and radiological impacts are very low, but the paragraph quoted above excludes the consideration of the impact of any pre-existing, migrating contamination. It is unclear whether the claim is made in the context of the limited scope of this study (e.g. excluding known tritium leaks) or whether it is a judgement being made about the acceptability of risks from the existing leaks migrating off-site. LLW Repository Ltd should be clear on this matter in future submissions.

2.1.3 LLW Repository Ltd also state that:

“It is important to see this study in the context of a range of options studies that have been undertaken by the LLWR since 2002 and those that will be undertaken in the near future (see subsection 2.1).”

This statement does not explain whether the current study replaces or builds upon previous options studies. Numerous option studies either already exist or are being planned; it is very difficult for the reader to discern the scope and boundaries of these different studies or the degree to which confidence can be attached to them.

2.1.4 In Section 2, LLW Repository Ltd state that:

“In the current study, we have tried to focus on the decision logic i.e. the reasons for our choices rather than on the quantitative analysis of different options.”

The report fails to explain in detail the approach and methodology for evaluating the options in practice. The evaluation process may be clearer to those who participated in elements of the work, but it is less apparent to the reader with access only to the documentation provided in response to Requirement 2. However, detail may also be lacking because the methodology relied relatively heavily on qualitative judgements by the project team. Such judgements are often inherently difficult to document, which contributes to an apparent lack of detail and an overall impression of a lack of transparency.

2.1.5 Reference is made in Section 2.1 to identifying “key uncertainties” but these are not identified in the report.

2.1.6 The discussion in Sections 2.3 and 2.4 of Volume 2 reflects a protracted history of options studies from 2004 to 2008. Taken together, it is difficult for the reader to discern the coherence in the sequence of studies or why LLW Repository Ltd revisited the options in 2007/08. We suggest it would perhaps be better to draw a line under the earlier options

work and instead just state the shortfalls and limitations of these studies that make further options studies necessary. Recent options groupings represent a better definition of the spread of options available than that considered in 2004. In particular, the option to 'unpack' the possibilities of partial retrievals is a big step forward.

- 2.1.7 Section 2.4.5 of the submission concludes that "further work is identified". One of the main weaknesses of this study is the lack of clarity on the scope and definition of the "further work" identified in Section 7.
- 2.1.8 In Section 4, it would have been instructive to present a list of the 50 options that have been screened out as a table in this volume (ideally with a brief statement of the reason(s) why each was screened out). We agree with the independent evaluator's view (Collier, 2008b) that the term 'option' seems to be used rather loosely and indiscriminately.

2.2 Stakeholder workshops

- 2.2.1 The stakeholder workshops held in December 2007 and January 2008 are referred to in Volume 2, in the main text and in more detail in Appendix A. Further detail is provided in reports by Collier (2008a,b). We welcome LLW Repository Ltd's inclusion of stakeholders in the process, but we have a number of observations – both from the documentation and from our participation in the workshops – on the extent and nature of stakeholders' involvement.
- 2.2.2 We note the comments from the independent peer reviewer that say it was unclear at the workshop held on 6 December 2007 what was required of stakeholders (Collier, 2008a). The reviewer's comments about the workshop held on 17 January 2008 (Collier, 2008b) also suggest that the day was not genuinely interactive, but a series of LLWR presentations. These comments tally with our observation that the role of the workshops, and the wider involvement of stakeholders in the process, were not as well defined as they might have been. Given that we see the options assessment process as incomplete, this is not simply a historical observation: we expect to see a more clearly defined role for stakeholders in future work in this area.
- 2.2.3 We note that the structure and format of stakeholder workshops can have a key bearing on their output. In this case, LLW Repository Ltd framed the questions and presentations in a particular way, stressing advantages and disadvantages of a range of options as they saw them. Had the workshops, for example, started with presentations on how other countries are dealing with their historical buried wastes, the stakeholders might have been more inclined to suggest that some of the same approaches should be applied to the LLWR.
- 2.2.4 The heavy reliance of the assessment methodology to date on the judgements of the project team (as noted above) also makes the role of stakeholder consultation unclear. Independent reports of the stakeholder workshops suggest they were not designed to elicit effective stakeholder participation, at least not in the sense this is normally understood. Certainly our impression was more of stakeholders being informed about what the operators were doing and being invited to comment, rather than stakeholders being asked to contribute to reaching decisions. This impression is reinforced because LLW Repository Ltd's position on the options appears to have changed little – if at all – as a result of the workshops. As the work continues, we expect to see more explicit evidence that stakeholders' concerns are being accurately identified and addressed.
- 2.2.5 One particular stakeholder concern is worthy of further comment here. The tables in Appendix A of Volume 2 present a summary of discussions from workshop participants ("discussion on the day" column). During the workshops, we heard several stakeholders indicate clearly that they were concerned about anecdotal evidence of past disposal practices; in our view these comments are not sufficiently reflected in the summary of the workshop, nor followed up in the subsequent discussion of options (see particularly the discussion of retrievals in Section 2.3 of this review).

2.3 Strategic options

- 2.3.1 Sections 5.3–5.9 of Volume 2 of the submission summarise review studies of caps, engineered barriers, coastal defences, vertical drains, retrieval, institutional control and *in situ* remediation. These studies are documented in more detail in supporting reports (Grimwood, 2008; Paulley, 2008a–b; Penfold, 2008; Towler, 2008a–b). For each technology, the relevant section presents a discussion of the technology, its pros and cons and a selective review of international practice. These sections sometimes point to the need for ‘further work’ on a technology, but these issues are not discussed later in the report and no actions or recommendations are made to enable these ‘work needs’ to be identified and managed.
- 2.3.2 The review of technologies and practices worldwide draws to a significant extent on reviews of national near surface disposal practices, carried out by international organisations such as the International Atomic Energy Agency (IAEA). These IAEA reviews are an entirely legitimate source of such information, but we note that some of the discussion in these studies relate to cases in which the long-lived content of the waste is low, and so the emphasis in disposal is very much on containment of the waste by the engineered barriers for a few hundred years. The technologies and practices described in these reviews could not, therefore, be applicable automatically to the LLWR situation which has a significant long-lived inventory. We have no reason to suppose that this limitation has necessarily been ignored – indeed it is highlighted in the discussion of institutional controls – but we expect to see it acknowledged explicitly in the context of cases where the difference in wastes would significantly affect the applicability of the technology or practice.

Caps and engineered barriers

- 2.3.3 The discussion of caps and engineered barriers in the text and supporting report (Grimwood, 2008) appears reasonable but is essentially inconclusive. We expect to see more focused discussion in the future leading to substantiated definitive proposals for suitable technologies.
- 2.3.4 Section 7.3.1 of Volume 2 suggests that a delay in the installation of the final cap could have benefits in terms of maintaining strategic flexibility. This is of course a valid consideration, but will need to be weighed against the potential benefits of early capping. At this stage we note in particular that the work to update the performance assessment is based on the assumption that the final cap is in place; the full ESC will need to include an analysis of performance during any period – shorter or longer – in which only the interim cap is in place.

Coastal defences

- 2.3.5 The analysis of the potential utility of coastal defences in the main text and supporting report (Towler, 2008a) is reasonable. We agree with the general conclusion that, while we cannot foresee future developments or what future generations might decide to do, we could not approve a case for the long-term safety of the LLWR that relied on coastal defences being maintained for several hundred years or more.
- 2.3.6 However, we find no discussion about whether there are any feasible measures that might protect the waste against disruption even when the site is eroded, for example, ‘armouring’ the facility in such a way that it will tend to flood rather than be eroded. Such measures might provide protective benefits irrespective of how the coastline evolves. Of course, any such measures may be limited in the same way as coastal defences (i.e. they could not be assumed to remain effective without active maintenance). LLW Repository Ltd may have considered the possibility of these solutions and discarded them as unfeasible. However, given the fundamental nature of the erosion issue, we expect to see every plausible avenue explored for protecting the waste, and where potentially plausible options are not pursued we expect to see the reasons documented.

Vertical drains

- 2.3.7 Volume 2 summarises a discussion that is covered in more detail by Paulley (2008a). The discussion reaches a tentative conclusion that vertical drains may be a useful component in an optimised system of engineered features, but suggests they are likely to play a secondary role if any.
- 2.3.8 We agree with Paulley's (2008a) observations about the lack of evidence for the reliability of vertical drains over long time periods. This is particularly important when set alongside the conclusion that vertical drains would appear to have an important role when the primary engineered barriers start to degrade (i.e. in the long term). If vertical drains are included in the final closure design, we expect to see a demonstration that they can be relied upon to perform their designated role.
- 2.3.9 We also highlight our concerns about the principle of using vertical drains that are designed to direct water into the deep groundwater (rather than, for example, into underground tanks or a pipeline to sea). Such a design feature does not fit obviously with modern principles of groundwater protection, particularly as embodied in European legislation. Depending on how it is transposed into national law, it is possible that the Groundwater 'Daughter' Directive (2006/118/EC) could effectively prohibit vertical drains of the design proposed, particularly if they are designed to operate routinely (rather than as a contingency that would operate only if a near surface release is threatened). It could be coincidental that the European examples of vertical drains covered in the submission all employ underground tanks. This may be because the facilities are designed for wastes with very low long-lived content and so have design lifetimes compatible with the life of tanks, but it may also reflect some unease in Europe with the concept. We will maintain a dialogue with LLW Repository Ltd on this matter as the legislative situation develops.

Retrieval

- 2.3.10 Retrieval (or selective retrieval) of waste is one option that has significant potential to reliably reduce long-term risks. Table 6.1 of Volume 2 shows that bulk or local retrieval is potentially the most reliable and effective method to reduce threats in terms of both the likelihood and the consequences that may arise from human intrusion, coastal erosion, groundwater and gas scenarios.
- 2.3.11 The discussion about international practice in Section 5.7.2 of Volume 2 relies on information from recent IAEA reports, but important case studies of exhuming waste from historical trench burials at Hanford are not mentioned (although information on these is readily available on the Internet), even to explain why they have not been considered further. Similarly, there are relevant case studies on retrieval at the other US reprocessing site at Savannah River that are not mentioned here. The Idaho site is mentioned briefly (USDoE, 2004 and 2005), but the discussion does not acknowledge the apparent similarities between this site and the potential retrieval of waste at the LLWR (in terms of targeted retrievals of some 12,000 m³ of waste). The discussion about the Idaho site also fails to explain why (if this is indeed the LLW Repository Ltd's position) it is not considered a good analogy.
- 2.3.12 Further discussion of the experience and plans for retrieval at Dounreay (LLW pits and ILW shaft) would also be beneficial, particularly given the similarities with the LLWR and proximity of the Dounreay facilities to the sea.
- 2.3.13 Unlike the other six options discussed in Sections 5.3–5.9 of the submission, the potential advantages of retrieval are not discussed, either in the main text or the supporting report (Paulley, 2008b). Perhaps the benefits are considered self-evident, but some readers might suspect that the authors were biased against this particular option. Instead, the text and discussion in Table 5 dwells exclusively on the difficulties of retrieval. One advantage that is not self-evident, and is not acknowledged anywhere in Volume 2 as an advantage, is that retrieval would also help to allay suspicion that significant quantities of unauthorised waste may have been disposed of in the trenches in the 1960s and 1970s. We note that

LLW Repository Ltd are embarking on a programme of interviews with past employees and others to investigate the anecdotal evidence concerning past practices. This work aims to reduce uncertainty about the inventory, but it would be logical for the assessment of options also to acknowledge explicitly that retrieval would have the advantage of demonstrating once and for all what is in the trenches. This may not be a technical or quantifiable benefit, and it may well be that it is outweighed by the disadvantages of large scale retrieval, but it is a real consideration and it would be better if the issue were addressed head-on.

- 2.3.14 We agree with LLWR that the possibility of selective retrieval is a key question to explore further. The criteria for 'intervention' should be investigated; we recommend a discussion on the alternative assessment contexts employed at sites in the USA and elsewhere where decisions on retrieval have been made, and the reasoning behind the decisions.

Institutional control

- 2.3.15 We recognise the merits of discussing the potential benefits and limitations of institutional control. However, the discussion in the main text and supporting report (Penfold, 2008) does not fully distinguish between the roles of institutional control in satisfying different regulatory requirements. When the intention is to demonstrate that actual risks will be sufficiently low by comparing the results of assessments with numerical criteria, then those assessments need to err on the side of caution (to account for uncertainties). This is why our guidance stipulates that the long-term safety of a repository should not depend on an unreasonable reliance on human action. This means that institutional control may not be *assumed*, for the purposes of the ESC, to remain effective for longer than a defined period.
- 2.3.16 The guidance does not, however, mean that the *possible or probable* benefit of a longer period of institutional control should be ignored in optimisation. In the context of optimisation assessment needs to be more realistic so as not to distort the balancing of risks, costs and benefits. Nothing in the environment agencies' guidance is intended to suggest that planning for a longer period of institutional control is not acceptable – indeed, if the operator identifies benefits from such an approach then we would expect them to take those into account in considering the optimum closure strategy.
- 2.3.17 On a minor note in this context, we would add that the IAEA documents cited in Section 5.8.2 are from the Technical Reports Series, not the Safety Standards Series. As such, they provide information on practices and experience in Member States, but do not provide consensus IAEA guidance on what should be done.

In situ remediation

- 2.3.18 Towler (2008b) provides a reasonably comprehensive and well reasoned analysis of the various *in situ* remediation options that exist, their potential benefits and their potential limitations. The analysis and conclusions seem to be reasonable in terms of the potential value, in respect of the groundwater pathway, of *in situ* remediation of all or most of the waste in the trenches. However, we note two points that are mentioned only briefly in Section 3.2 of Towler (2008b):
- (a) The effects of any *in situ* remediation on pathways other than groundwater are an important consideration in light of the current understanding of the LLWR's likely evolution. It is important in particular to consider how remediation may affect exposure pathways during coastal erosion.
 - (b) The balance of arguments for and against the selective use of *in situ* remediation techniques to target particular areas of waste might differ significantly from pros and cons relating to the application of the same techniques to all or most of the waste.

2.4 Conclusions and future actions

- 2.4.1 It is difficult to trace conclusions from the main text, perhaps because they are based on judgements reached by internal teams rather than on the results of a decision-aiding methodology. As indicated previously, this does not in any way invalidate the conclusions, but it is a failing in the documentation. The GRA makes clear that expert judgements should be documented systematically and traceably, just as empirical data or other literature would be referenced.
- 2.4.2 The most fundamental weakness in Volume 2, however, is that it fails to present a programme or strategy for managing the next steps in the options assessment process. The process is clearly not yet complete, and there are various references in the submission on the need for further work. However, there are no specific actions or commitments to conduct work to address the known shortfalls or key uncertainties.

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2 Conclusions in relation to Schedule 9 Requirement 2 and recommendations in relation to the environmental safety case

- 3.0.1 Volume 2 describes and briefly evaluates a wide range of technologies that have been used or proposed around the world that might conceivably be applied at the LLWR – particularly to the trenches – to help reduce the long term impacts from the buried waste. It goes on to describe the process used by LLW Repository Ltd to evaluate systematically which of the technologies (if any) could be beneficial at the LLWR. The advantages and disadvantages of applying these technologies are discussed; the optimum strategy for managing the risks from the site is consequently outlined.
- 3.0.2 On the basis of this work, LLW Repository Ltd identify some technologies that they think should be applied (e.g. a substantial final cap over the site). They effectively rule out several options on the grounds that they would not be beneficial. The complete retrieval of all waste from the trenches is notably eliminated because it would involve major disruption and expense, would expose workers to significant risks, and would require large amounts of waste to be re-disposed in another facility. The use of coastal defences to protect the LLWR from erosion is also ruled out because it would be impossible to guarantee that such defences would be maintained over the necessary timescales. LLW Repository Ltd also identify a range of technologies that might be beneficial (individually or in combination) depending on precise circumstances. They propose to treat these technologies as a 'toolkit', to be selected and applied, if and when appropriate, as more detailed information is obtained. The toolkit technologies include:
- (a) selective retrieval or *in situ* immobilisation of specific wastes that contribute significantly to the overall risk;
 - (b) construction of vertical drains and an underground cut-off wall around the site to divert radionuclides in leachate downwards to greater depth;
 - (c) retention of institutional control over the site.

Provisionally, LLW Repository Ltd propose an optimum strategy that involves construction of a cap, vertical drains and a cut-off wall, but no retrieval or further immobilisation of emplaced waste. However, this strategy is presented as an interim position, subject to further investigation and optimisation, which must take account of new information and developments in understanding which may arise as work continues towards the fully updated ESC in 2011.

- 3.0.3 The overall response to Requirement 2 relies heavily on reductions in the assessed risks which were calculated in the performance update (as compared to those calculated in the 2002 PCSC). The response does not place much emphasis on proposals that would reduce the actual risks (e.g. by retrieving or immobilising wastes). Indeed, at times the submission seems to blur the distinction between assessed and actual risks. It is entirely legitimate for LLW Repository Ltd to consider potential actions to reduce actual risks in the context of the best available information on the assessed risks. Any action will inevitably incur costs and have some negative impacts; these have to be weighed against the likely reduction in risks. If the full ESC were to confirm that the levels of assessed risk were similar to those suggested by the performance update (Volume 5), then clearly there would be less incentive to consider intrusive methods to reduce risks than if risks were at the

levels calculated for the 2002 PCSC. However, in the absence of such confirmation, we consider that Requirement 2 refers primarily to options to reduce the actual risk, and our recommendations for follow up work arising from Requirement 2 are based on that premise. LLW Repository Ltd may choose to adjust their response to those recommendations on the basis of developing confidence (or otherwise) in their risk assessments, but they would do so at their own risk.

3.0.4 In Volume 2, LLW Repository Ltd review national and international developments in best practice for minimising the impacts that arise from past disposals in the trenches at the LLWR. This review covers different options for reducing the peak risks from the deposit of solid waste on the site. LLW Repository Ltd have investigated options for reducing the peak risks from the groundwater and gas pathways, from potential site termination events and from possible human action in the future. In this respect LLW Repository Ltd's response goes beyond the scope of Requirement 2. Additionally, LLW Repository Ltd has used the reviews of best practice and options to outline a proposed optimum strategy for the site, subject to some further developments. Our overall assessment is that the work reported in Volume 2 substantially satisfies Requirement 2 and in some respects goes beyond it. However, it falls short of what we will expect from the full ESC, particularly for the following reasons:

- (d) The review of options for reducing the peak risks needs to be developed further. LLW Repository Ltd have developed and briefly characterised a reasonable set of 'tools' – potentially useful methods that might contribute to risk reduction measures. However, LLW Repository Ltd now need to define and compare systematically the specific, coherent options for reducing risks.
- (e) The review of national and international developments needs to be complete and up-to-date. Some potentially relevant and reasonably well known examples have not been mentioned or have been considered only briefly. It is not clear whether these are simple omissions or whether LLW Repository Ltd has considered these examples and judged them not to be sufficiently relevant. All relevant examples will need to be documented in detail and taken into account in the consideration of potential detailed strategies.
- (f) Although stakeholders have been engaged, the structure of the process to date has given stakeholders limited scope for active and meaningful participation in decision making.

3.0.5 We therefore conclude that LLW Repository Ltd has substantially satisfied Requirement 2. We note that there are some minor areas specific to Requirement 2 that need further work, but we consider that these issues are best addressed as part of the on-going work programme towards the full ESC. However, further work will also be needed so that the full ESC addresses in more detail some of the issues arising from Requirement 2. First and foremost, LLW Repository Ltd need to develop and implement a detailed follow-up action plan to apply the methodology developed in the work to date. This plan (**Category A recommendation** – see para. 1.5.4) should include details of how they intend to:

- (a) identify more specifically any gaps and uncertainties in their knowledge and understanding of the site, the wastes, the technologies and the impacts that have hindered meaningful comparison of specific risk reduction options to date. This should include, but is by no means limited to, investigating the anecdotal evidence concerning past disposal practices in the LLWR trenches;
- (b) address those gaps and uncertainties sufficiently to allow robust decisions to be made;
- (c) reconsider and compare the applicability of different technologies (and combinations of technologies) for reducing risks to provide soundly based assessments of the best practicable option;
- (d) involve stakeholders in the process in such a way that they can understand and meaningfully contribute to decision making.

In formulating this action plan, we would expect LLW Repository Ltd (**Category B recommendation**) to make their review of national and international developments

comprehensive, and complete their review of risk reduction options by defining an optimised strategy for the site.

3.0.6 Where the work so far has identified potentially useful technologies that are not currently considered 'available', the follow-up action plan should aim to identify any advance(s) in the technology that should trigger a re-evaluation of its applicability. The plan should indicate whether LLW Repository Ltd intend to:

- (a) actively support R&D to achieve the relevant advance(s);
- (b) monitor progress on an existing or planned programme of R&D elsewhere;
- (c) wait for the relevant advance(s) to arise from an as yet unknown source.

The plan should also set out LLW Repository Ltd's strategy for monitoring and assessing potentially useful technologies that may emerge in the future. In particular they should outline mechanisms by which they will keep up-to-date about the 'state of the art', identify emerging technologies that merit closer attention and feed them into the system described above for already identified technologies.

3.0.7 In carrying out this further work and in documenting the whole process in the ESC, we expect LLW Repository Ltd (**Category D recommendation**) to continue to:

- (a) make clear the connections between the various phases of work completed since the 2002 PCSC, indicating where results from earlier stages have been fed into and used in later stages and where there have been changes in approach;
- (b) clarify the roles assigned to stakeholders in the different steps of the process, how they performed those roles and where and how their contributions were taken into account in decisions;
- (c) ensure that the evaluation of examples of practices in other countries takes account of any differences in the definition of LLW compared to the UK;
- (d) set out all of the potential advantages and disadvantages of applying such practices in the UK, but make clear which of these have been given weight in decisions (and why);
- (e) make clear when expert judgement has been used, the conclusions of that judgement and gives the reasons for their conclusions where these are known;
- (f) take account of our observations on the identified technologies as documented in Section 2.3 of this review.

3.0.8 While we accept that the work for Requirement 2 rightly focused on an assessment of best practice to reduce the peak risks from the vaults, the full ESC will need to demonstrate also that best practice has been, is being and will be applied to keep the risks from the vaults as low as reasonably achievable. Our expectations in this regard are discussed in more detail in the Overview document.

Appendix 1: Review of supporting reference

This appendix gives detailed comments on a document cited in support of the Requirement 2 submission. The main points arising from our review of this document are, however, addressed in the main text.

Amin S, Management Options for the Optimisation of the LLWR at Drigg, Nexia Solutions (07)8842 Issue 2

We recognise that the primary purpose of the work reported here is to identify all the potentially useful technologies and to avoid any options being missed or prematurely rejected. In this case, therefore, we can see why some technologies have been listed as 'options' despite apparently offering little in the way of potential benefit to the specific case of the LLWR. However, we would wish to be assured that whilst the inclusion of such technologies provides confidence in the completeness of the assessment, it does not detract from the attention given to the more realistic candidate options. In some cases, these latter options have been presented in rather generic terms (e.g. 'physical barriers', 'solidification/stabilisation') – presumably they will be developed in more detail after the options have been screened.

In particular, a large section of the report is devoted to technologies that are specifically designed to remove or destroy organic contaminants, which are not a major concern for the LLWR. It is right that these methods are discussed, but perhaps they might reasonably have been addressed as a group rather than individually.

It might nevertheless have been worth noting in the introductory sections some basic points, for example that unlike some contaminants whose harmful nature stems from the chemical properties of molecules, radionuclides cannot be destroyed by any of these technologies (i.e. they can only be removed from the soil or groundwater in the form of secondary waste). The introduction should make it clear that technologies (other than physically removing the waste itself) need to be effective for very long time periods (with no active maintenance or operation).

For completeness, the use of tables might help to summarise the general advantages and disadvantages of excavation and pumping, which would need to be considered alongside the specific advantages and disadvantages of technologies that require excavation or pumping. Section 3.5 of the submission touches on this aspect, but does not further develop the theme.

We recognise that the authors would not wish the order in which options were presented to appear in any way prejudicial. However, their essentially random approach does make it difficult to follow (e.g. the section on soil washing comes several pages after the section on enhanced soil washing).

List of abbreviations

ALARA	As low as reasonably achievable
BNFL	British Nuclear Fuels plc
BNGSL	British Nuclear Group Sellafield Limited
Defra	Department for Environment, Food and Rural Affairs
ESC	Environmental safety case
GRA	Guidance on Requirements for Authorisation
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
IAF	Issue assessment form
ILW	Intermediate level waste
ISO	International Organization for Standardization
LLW	Low level waste
LLWR	Low Level Waste Repository near Drigg, Cumbria
NDA	Nuclear Decommissioning Authority
NII	Nuclear Installations Inspectorate
NRPB	National Radiological Protection Board
OESC	Operational environmental safety case
PCSC	Post-closure safety case
R&D	Research and development
RSA 93	Radioactive Substances Act 1993 (as amended)
SLC	Site licence company
UKAEA	United Kingdom Atomic Energy Authority
UKNWM	United Kingdom Nuclear Waste Management Ltd

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