LLW Repository Ltd

LLWR Environmental Safety Case

Analysis of Issues Raised in RECALL Interviews

A report prepared by Serco for and on behalf of the Low Level Waste Repository Site Licence Company.

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Analysis of Issues raised in RECALL interviews

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List of Acronyms/Abbreviations

Acronym/Abbreviation	Meaning
ALARP	As Low As Reasonably Practicable
BNFL	British Nuclear Fuels Ltd
CfA	Conditions for Acceptance
DML	Devonport Management Limited
DU	Depleted Uranium
EA	Environment Agency
ESC	Environmental Safety Case
HF	Hydrogen Fluoride
HMIP	Her Majesty's Inspectorate of Pollution
HP	Health Physics
HSR	Health and Safety Regulations
ILW	Intermediate Level Waste
LETP	Liquid Effluent Treatment Plant
LLW	Low-Level Radioactive Waste
LLWR	Low Level Waste Repository (near Drigg in Cumbria)
LTP	Lifetime Plan
MoD	Ministry of Defence
MoS	Ministry of Supply
NII	Nuclear Installations Inspectorate
PCM	Plutonium Contaminated Materials
PCSC	Post-Closure Safety Case
RSA	Radioactive Substances Act
SLC	Site Licence Company
UK	United Kingdom
UKAEA	United Kingdom Atomic Energy Authority
UKRWI	United Kingdom Radioactive Waste Inventory
VLLW	Very Low Level Waste
WAC	Waste Acceptance Criteria
WAMAC	Waste Monitoring and Compaction (facility)

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Executive Summary

The Low Level Waste Repository (LLWR) is undertaking a programme of work to underpin the assessments made as part of an Environmental Safety Case (ESC) for submission to the Environment Agency in 2011. Part of this programme of work is the production of a robust and defensible inventory of past and future waste disposals.

The study reported here describes part of the review of past disposals that were made to the trenches on the LLWR site. Anecdotal evidence suggested that there may have been disposals to the trenches from Sellafield that were not recorded and that might significantly affect the estimates of the environmental impact of the Repository. The LLWR therefore undertook a series of interviews with current or retired staff from Sellafield and/or the LLWR that had operational and other relevant experience. This was done with the intention of eliciting information on past disposal practices and hence determining any significant impacts on the assumed inventory of wastes in the trenches. A previous study involved the review and documentation of the 28 RECALL interviews, the outcome of which was the identification of a comprehensive list of 45 issues that were identified as having potential to impact on the disposal inventory. A preliminary analysis resulted in the closure of a number of issues and the development of a series of specifically tailored actions to steer further work to fully assess the remaining issues.

This document provides a summary of the information gathered for each of the identified issues. The approach to assessment varied for the different issues, but the following outlines the most common methods:

- Further analysis of existing records, held on- and off-site, to determine if issues are already addressed within the existing inventory and whether quantitative data are available;
- If existing records indicated that the issues were not adequately addressed in the existing inventory, simple scoping calculations to quantify the likely impact of the issue on the overall disposal inventory to determine significance;
- Where a significant effect was considered possible, discussions with LLWR staff and detailed examination of records was undertaken to develop greater understanding of the issues and to improve the quantification where possible.

When assessing the potential impact of a disposal on the inventory the activities of key radionuclides or hazardous wasteforms were considered in relation to the current inventory. The threshold above which a disposal was considered significant, was 5% and 1%, respectively, for waste streams already included in, or omitted from, the current inventory. The analysis of individual issues has lead to a range of conclusions. Many of the issues were concluded to have no significance for the inventory of disposals to the trenches; other issues might have caused an overestimation of the inventory whilst others might have led to an underestimation. The three categories are outlined below:

- *Issues with no impact on the inventory*

  Some issues, for example increasing Sellafield discharge limits (Issue 24) or the disposal of furnace liners in the Sellafield (B291) trenches provided background and context on the running and management of the LLWR site and/or Windscale/Sellafield, during the period of trench operations but did not directly relate to disposals to the LLWR trenches. In other cases, issues were raised regarding potential disposals to the trenches; for example the question of whether waste from the Pile 1 and Chernobyl accidents (Issues 31 and 33, respectively) had been disposed in the trenches. On further investigation, evidence was found that demonstrated that no such disposals had been made to the trenches and thus could not affect the inventory.

- *Issues with the potential to increase the inventory*

  This study has identified several issues which might have contributed to an underestimation of the current trenches inventory of key radionuclides or certain other materials (e.g. oil (Issue 11) and asbestos (Issue 36)).

In some cases, for example the disposal of PCM from the Magazines (Issue 32) or the disposal of Trimphone dials (Issue 22), investigation demonstrated that the disposals were already accounted for in the inventory of the trenches, and that the issue did not represent a potential change to current inventory estimates.

Other issues raised have the potential to increase the trench inventory. In some cases this is because they refer to disposals which cannot be unambiguously located in existing records, for example the disposal of Pu/Am fused salts (Issue 6) or contaminated stainless steel tanks (Issue 9). In other cases the issue related to a practice which might have led to an identified disposal having its radionuclide content underestimated, for example packaging wastes to provide additional shielding (e.g. painters handbags and lead sandwiches in Issue 5); the shielding of sacks within skips (Issue 13) or the disposal of wastes in another building's skips (Issue 27). In cases of these sorts, where documentary evidence was lacking, scoping calculations were performed to evaluate the potential effect of the issue on the inventory of the trenches. In no case was it found that the disposal practice or unrecorded disposal had the potential to materially affect the existing trench inventory.

- *Issues with the potential to reduce the inventor*y

Other issues have been identified which would have caused an overestimation of the inventory of key radionuclides. Such issues include the disposals of non-contaminated waste from the site clearance exercises (Issue 8) and 'clean' laboratory waste (Issue 10); the potential lack of background correction when monitoring sacks of LLW (Issue 44).

Perhaps the issue with the most potential for identifying an overestimation of the inventory raised during the RECALL issues was the already known issue of the monazite disposal (Issue 7). There is limited information available to suggest that 502 tonnes of the sand, representing some 8% of the Th-232 inventory, were actually removed from the trenches. No documentary evidence was found, however, despite extensive searches.

On balance, however, no changes are recommended to the inventory as a result of the RECALL exercise. In the case of Monazite sands, no supporting evidence was found for their removal, and the cautious approach is therefore not to modify the inventory. In the case of other issues, whilst there may be evidence for a real effect, the magnitude of the effect cannot be quantified reliably. Under these circumstances the cautious approach is to make no change to the currently assessed inventory of the trenches.

In summary, for all issues analysed, any impact of issues raised in the RECALL process on the current inventory of the trenches is likely to bounded by the current uncertainties acknowledged in the trench inventory and hence in assessments of the performance of the facility. As a result, no changes to the inventory of disposals to the LLWR trenches have been recommended in response to this study and no issues were identified that would materially affect the conclusions about the safety of the Repository.

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1 Introduction

1.1 Overview

The Low Level Waste Repository (LLWR) is undertaking a programme of work to underpin the assessments made as part of an Environmental Safety Case (ESC) for submission to the Environment Agency in 2011. Part of this programme of work is the production of a robust and defensible inventory of past and future waste disposals.

The study reported here describes part of the review of past disposals that were made to the trenches on the LLWR site. Anecdotal evidence suggested that there may have been disposals to the trenches from Sellafield that were not recorded and that might significantly affect the estimates of the environmental impact of the Repository. The LLWR therefore undertook a series of interviews with current or retired staff from Sellafield and/or the LLWR that had operational and other relevant experience. This was done with the intention of eliciting information on past disposal practices and hence determining any significant impacts on the assumed inventory of wastes in the trenches.

A previous study [1] involved the review and documentation of 28 RECALL interviews with current and former staff members on the LLWR and Sellafield sites. The outcome of this work was the identification of a comprehensive list of issues that could potentially have an impact on the current disposal inventory. To investigate these issues further LLWR Ltd instigated a study to evaluate each issue in terms of any potential impact that it may have on the disposal inventory for past disposals to the LLWR trenches.

A total of 45 issues were identified as having a potential to impact on the disposal inventory. A preliminary analysis resulted in the closure of a number of issues and development of a series of specifically tailored actions to steer further work to fully assess the remaining issues. This document provides a summary of the information gathered for each of the identified issues. All assessments were based on the information obtainable as part of the work to develop a robust and defensible inventory to support the 2011 ESC through examination of available records held by LLWR and elsewhere.

1.2 Background

The history of the LLWR site for the disposal of Low Level Waste (LLW) has previously been described in Reference 1. Briefly, in the period between 1959 and 1995 LLW was disposed of to a series of seven clay-lined trenches at LLWR by ‘tumble-tipping‘ material: a process similar to that performed on municipal landfill sites. During this period, processes for disposal of LLW at LLWR changed significantly. The most important single change, in the context of deriving an inventory, was in 1988 when changes to the disposal authorisation under the Radioactive Substances Act 60 (RSA 60) required detailed characterisation of the waste streams in terms of the radionuclide and materials fingerprints. Before this time, records often contain little more information of use in deriving an inventory than consigner, date of disposal and disposed volume. As a result, deriving an inventory for the trenches at LLWR has been complex. The most recent detailed evaluation of the trench inventory has been reported by Wareing *et al* [2]. This document contains a detailed description of the way in which the trench inventory was derived from the available records: a brief overview is provided below.

The available records were examined, and divided into two categories: ‘key consignments’ and ‘routine consignments’.

‘Key consignments’ were identified based on the quality of the information available for the consignment and its likely significance in inventory terms. Data for these consignments were captured directly from the paper-based disposal records. The quality of the information for these disposals is likely to be relatively high as it is based on direct characterisation.

The remaining disposals were assigned as ‘routine consignments’. Radionuclide and material fingerprints were assigned on the basis of information gathered on characterised streams believed to be similar in nature, and inventories for the disposals calculated by backfitting this information to reported disposal volumes. The inventory information on routine disposals is therefore inevitably of lower quality than that for key disposals.

It is important to recognise that the trench inventory has been derived largely on the basis of expert judgment, making best use of the information available concerning the origin and nature of the trench disposals which included their volume, mass, and activity content. There appears to be only limited information on the methods that were used to measure or estimate the data that were entered in the historical disposal records. This is the case for both routine and key consignments.

The approach adopted in this study is to focus on those radionuclides that are potentially significant contributors to the radiological risk via one or more of the potential exposure pathways. These key radionuclides (C-14, Cl-36, Tc-99, I-129, Th-232, Ra-226, U-234 and U-238, Pu-239, Pu-240, Pu-241 and Am-241) are expected to have a significant effect upon the ESC on the basis of analyses undertaken for the Requirement 2 submission to the Environment Agency in 2008 [3, 4, 5].

However, it is important to note that even disposals containing significant quantities of key radionuclides (see Section 3 for determination of thresholds) that would require amendment to the current inventory, are unlikely to be on a scale sufficient to affect the safety arguments which underpin the 2011 Environmental Safety Case or the conclusions reached.

2 Grouping of Issues

Following the identification of the issues of potential significance to the trenches inventory from the RECALL interviews [1], the issues were grouped according to their nature. The grouping is described in the aforementioned report and outlined briefly below. The detailed assignment of the issues to each group is given in Appendix 1.

- **Group 1: Unusual dispatches of materials of potential radiological significance**
  During the course of the interviews a number of ‘one-off’ dispatches to the trenches were described. It is possible that some of these wasteforms contained high activity levels and will have included alpha wastes and the key radionuclides. Some of these dispatches included materials that could have a significant impact on the inventory, such as plutonium-americium fused salts from the laboratories, source trays, MoD navigation equipment and dials containing radium, drums containing plutonium-contaminated materials (PCM) from Springfields, contaminated stainless steel tanks and thorium sands.
- **Group 2: Disposal of materials of non-radiological significance**
  It was noted by a number of the interviewees that organic and flammable liquids such as diesel and hydraulic fluids were often disposed of in the trenches from Sellafield, certainly up until early 1972. The organic materials originated from both the large items of redundant machinery driven/placed in the trenches and the disposal of residual (non-active) contamination of previously used 200 litre type oil drums for disposal of some LLW (prior to 1972).
- **Group 3: Disposal of materials of very low/negligible activity**
  This group refers to non-active disposals, for example those waste streams collected by the site clearance team from around the Sellafield site. It was stated by several interviewees that the vast majority of the wastes going into the trenches was ‘clean’ and showed no traces of activity. The cost of disposal in the trenches was so cheap (cheaper that a municipal site) in the early days that it was found to be a cost-effective route for uncontaminated wastes. It was not until after the 1988 update to the RSA Authorisation that the cost of disposals started to increase significantly and consignors began segregation and minimisation of wastes.

- **Group 4: Disposal of material of potentially high radionuclide inventory**
  After review of the interviews given by people who had experience of consigning waste from Sellafield to LLWR, it became apparent that there were a number of methods used to dispose of waste that was regarded as being potentially beyond LLWR limits. This includes the methods such as 'painter's handbags', 'lead sandwiches', undocumented disposals (e.g. into another building's skip) and averaging, described in detail in reference [1].

- **Group 5: Identification of potentially inappropriate disposals**
  During the interviews, a number of incidents were recalled where an alarm had been raised as to whether some items in the trenches were disposed of correctly and to the standards outlined in the CfA[1]. Examples include the uncovering of a glovebox by Greenpeace, the Harwell Trimphones, incorrect disposal of C-14, misunderstandings surrounding the Chernobyl incident, and the uncovering of Trench 3 waste during the excavation of Vault 8.

- **Group 6: Quality of measurements**
  Although a few interviewees discussed the monitoring equipment and procedures that underpin the radiation measurements explicitly, there have been underlying questions on the quality of the data. These questions have been reinforced by a number of statements regarding the overestimation and associated uncertainties of the current trench inventory.

- **Group 7 – Issues not relating to disposals at LLWR**
  A number of the issues raised did not relate specifically to trench disposals, but provided background and context on the running and management of the LLWR site, and in some cases Windscale/Sellafield, during the period of trench operations. Some of the issues classified in this category have the potential to affect the inventory.

3 Methodology

3.1 Approaches for Evaluating the Issues

In investigating the issues raised in the RECALL interviews, a range of approaches was adopted to evaluate the significance of the issues, and if appropriate, determine the necessary changes to the inventory. The approaches used included:

1) **Contact with interviewees and employees:** for a few issues, clarification of the interviewee's previous comments was beneficial in determining their significance. Discussions were also held with several members of current LLWR staff in order to elucidate issues and identify appropriate sources of information.
2) **Archive and database searches:** this involved the identification and review of archived documents to elucidate several of the issues. Examples of the paperwork that was sought include: D4 disposal records; LLWR and Sellafield (Windscale) historic site procedures; Health and Safety Regulations (HSR); Incident Reports; and technical documents. Sources of data included the National Archives at Kew, Iron Mountain archiving company, and Sellafield and LLWR database searches.
3) **Review previous assessments:** this refers to the cases where previous studies have been performed. Where possible, the previous assessments were reviewed and an independent evaluation was performed where this was thought feasible and potentially beneficial.
4) **Scoping calculations:** some issues were examined by performing a series of scoping calculations to determine the potential impact on the inventory.

Flowcharts outlining the methodology for investigating and assessing issues from Groups 1 to 4 and 5 are shown in Figures 1 and 2, respectively. No methodology has been proposed for Group 6,

[1] The phrase 'Drigg limits' was commonly used by the interviewees. This was taken to mean the equivalent of the current 'Waste Acceptance Criteria'[1] (WAC), or 'Conditions for Acceptance' (CfA) as they were called at the relevant time.

since these issues would not have any material effect on the inventory. The individual steps are described in more detail in reference [1].

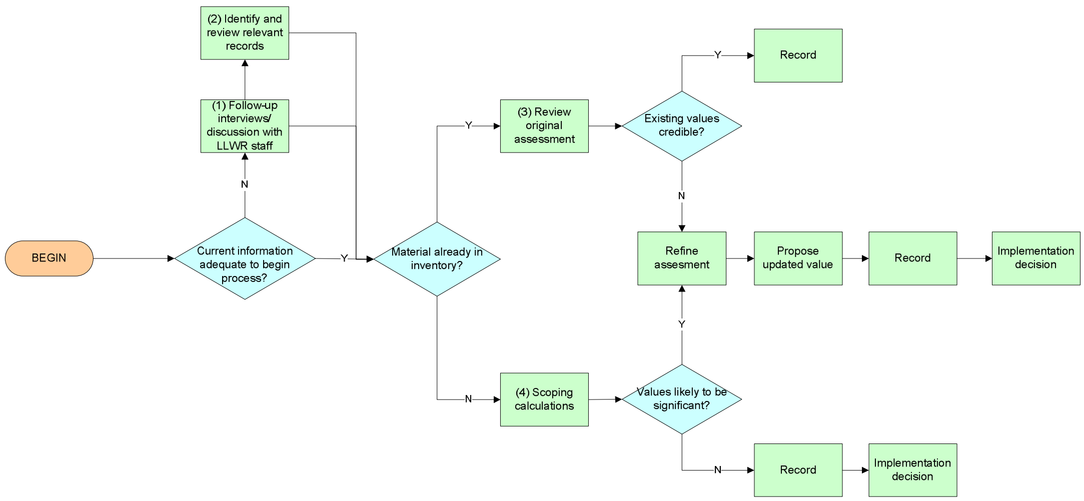

Figure 1 **Flowchart outlining the method used to investigate the issues raised in Groups 1 to 4.**

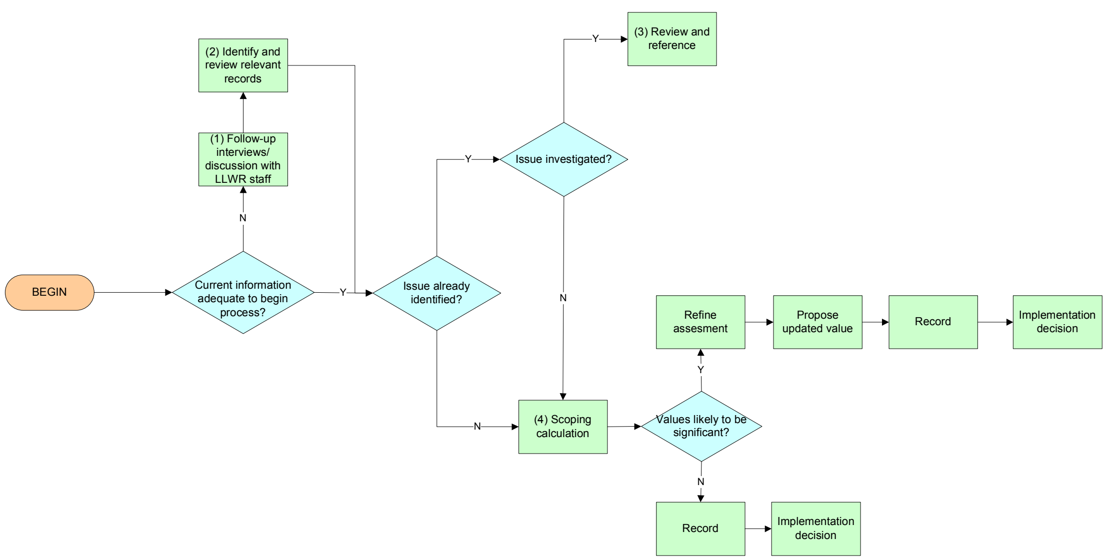

Figure 2 **Flowchart outlining the method used to investigate the issues raised in Groups 5 and 7.**

In many cases, the proposed methodology outlined in Figures 1 and 2 could not be followed in full as relevant documents or information could not be sourced, despite efforts by both Serco and LLWR staff. For example, it was often difficult to show conclusively whether a particular waste had been accounted for in the inventory, and locating disposal records of materials thought to be accounted for within the current inventory sometimes proved problematic.

3.2 Threshold for Assessment

The potential significance of any particular issue for the radionuclide inventory of the trenches will determine the amount of effort which can be justified in any analysis. In determining potential significance, it is important to consider the inherent uncertainties in the base inventory data. This section of the report discusses the methods by which the inventory of the trenches was established and considers the associated uncertainties. This discussion form the basis for the development of criteria against which the potential significance of an issue can be judged.

3.2.1 Developing the trench inventory

When developing the reference inventory, disposals to the trenches were regarded as ‘specific’ or ‘routine’.

Specific disposals were those where the associated activity caused significant perturbation to the trench inventory as evaluated at the time of disposal. Although the data relating to the these consignments is likely to be reasonably robust in comparison with those for other disposals, the data available do not always provide a direct measure of the inventory of the consignment and some analysis of the data, often involving assumptions, is required.

Setting to one side potential inaccuracies in the disposal records themselves, uncertainties in the derived inventory for routine disposals arise from two principal sources, as described in reference [6]:

- **The appropriateness of the fingerprint chosen for individual disposals:**
  Fingerprints assigned for routine disposals were derived from the Waste Tracking Database, supplemented by information derived from the 1994, 1998 and 2004 United Kingdom’s Radioactive Waste Inventory’s (UKRWI). The fingerprint information in the UKRWI is that associated with either waste streams generated at the time or waste streams projected to arise in the future. Even when the buildings consigning waste to LLWR in the 1950s and 1960s still consign LLW, it is far from clear that the fingerprints from current and future disposals are appropriate to historic materials. Even if the purpose of the building has remained the same, changes in practices over decades may well have had a material effect upon the waste fingerprint. This problem becomes more acute when a nominally matching fingerprint cannot be identified and an ‘average’ consignor fingerprint has to be adopted.
- **The way in which the fingerprint is applied:**
  An understanding of the quantity of waste in a disposal is a prerequisite to deriving a materials or radionuclide inventory from the fingerprint. In calculating the inventory of disposals to the trenches, the assumed bulk density of the wastes becomes a key factor, because:
  - Disposal quantities are generally recorded by bulk container volume. It is not clear how full individual containers were – to compound this uncertainty the efficiency with which the occupied space was used is unclear, and probably varied markedly from consignment to consignment depending upon the exact nature of the wastes in a given disposal.
  - Fingerprint data are quoted in terms of unit mass. A bulk density has therefore to be assumed for the wastes in order to apply the fingerprint. It is not clear that the bulk density assumed necessarily matches the values achieved in practice.

  In addition to the appropriateness of the fingerprint to individual consignments, uncertainties in the density of the disposals will add to the uncertainty in the derived inventory.

These uncertainties are difficult to quantify accurately, but analysis indicates that radionuclide activities will be bounded by an upper limit set at ten times the best estimate [7].

3.2.2 Deriving criteria for assessment

Setting a threshold for quantitative assessments beyond the ‘scoping’ level is inevitably a matter of balance. Too high a threshold and potentially significant effects may be missed. Too low a value and effort will be expended on matters of no significance to the 2011 ESC. The main factor considered when making the decision was whether the scoping calculation suggested a change to the inventory that is likely to affect assessments in the ESC in a material way, bearing in mind the uncertainties.

These judgments are inevitably case-specific, and must be made on an issue-by-issue basis. The following guidelines provided a starting point for decision-making:

- For waste streams already in the inventory of the trenches, does the scoping assessment suggest a change in the assessed content of any key radionuclide, in either direction, in excess of 5% of the total inventory of that radionuclide in the trenches? This value is chosen to ensure that the changes, when predicted using conservative assumptions, are likely to:
  - Be significant in the light of the uncertainties in the characterisation of the waste stream;
  - Generate a material difference to performance assessments.
- For waste streams not already in the inventory, a key radionuclide content in excess of 1% of the total inventory of that radionuclide in the trenches. The threshold here is relatively small in terms of the assessment, but is chosen to reflect the definition of a key waste stream from the forward inventory. However, no consideration can be given to including a particular disposal in the inventory without clear, auditable evidence pertaining to the details of the disposal.
- Detailed assessments should not be undertaken unless the data and methods available for the calculation will yield a more robust result than the scoping value.

The use of 5% and 1% thresholds, for assessing the significance of the activities of waste streams already included in or omitted from, respectively, the current inventory are consistent with the approach used for the forward inventory [7]. Disposals with activities of key radionuclides found to be above these thresholds would require amendment to the current inventory. It should be noted, however, that whilst this method of determining whether a disposal should be incorporated into the inventory is justifiable, any changes to the inventory on this scale are unlikely to affect the safety arguments which underpin the 2011 Environmental Safety Case or the conclusions reached.

4 Summary of Findings

The detailed analyses of each issue are described in the tables forming Appendix 2. Details of the work performed to investigate each issue are outlined and conclusions are formed as to the significance of each issue for the inventory of materials disposed to the LLWR trenches. In certain cases it was difficult to quantify some of the issues that might have lead to higher activity disposals but it is judged unlikely that any of the issues raised would affect the conclusions of the 2011 ESC. In no cases was it recommended that changes be made to the Inventory.

Initial assessment during the early stages of the work [1] suggested that the issues with the greatest potential to impact on the current inventory of disposals to the LLWR trenches were:

- **Issue 2:** Disposal of redundant uranium hexafluoride (‘Hex’) cylinders, into Trenches 3 and 4.
- **Issue 3:** Disposal of waste into another building’s skip without the knowledge of the building consignors.
- **Issue 5:** The disposal of lead sandwiches, painter’s handbags and other methods used to provide a level of shielding for higher activity wastes into building LLW skips.
- **Issue 6:** Disposal of plutonium and americium fused salts and/or plutonium and americium bearing liquids into Trench 2 (30 2.5 l Winchester flasks wrapped in lead from B229 laboratories pre-1971).
- **Issue 7:** Disposal of thorium containing ores and sands into the trenches.
- **Issue 11:** Disposal of various items of machinery in the trenches and flammable organic liquids such as petrol, diesel, oils, and greases. Includes the use of second hand drums containing solvent/oil residues up until 1972.

- **Issue 14:** During the excavation of the eastern wall of Vault 8, Trench 3 was disturbed. Two items of highly active waste were thought to have been exposed.
- **Issue 16:** Disposal of unirradiated natural uranium that could not go through the reprocessing plant, following an attempt to dissolve it in nitric acid.
- **Issue 17:** Disposal of alpha and beta contaminated source trays in the trenches.
- **Issue 34:** Each building now generates a waste fingerprint on which the radionuclide inventory, if its wastes, is based. Over time this may change as the plant operations change.
- **Issue 43:** Disposal of Springfield drums which may contain uranium residues.

The issue that initially appeared to have the strongest potential for effecting a change was that of the monazite disposal in Issue 7. There is limited information available to suggest that 502 tonnes of the sand, representing some 8% of the Th-232 inventory were actually removed from the trenches. However, upon reviewing the available evidence, this cannot be independently corroborated and thus it is necessary to concur with the original judgement of Wareing et al [2] that the materials remain in the inventory as a key consignment in order to be cautious.

In the case of other specific, or one-off disposals, such as the disposal of unirradiated uranium (Issue 16) or redundant uranium hexafluoride cylinders, assessment of the available information provided no clear evidence to support the alteration of the existing inventory, but scoping calculations indicated that the disposals would cause no significant change in the inventory data.

For some issues, little information was available upon which to base an assessment of radionuclide inventory despite extensive investigations of the records. The reported disposal of Pu/Am salts to Trench 2 (Issue 6) is a typical example. In these cases, the activity that would have to be associated with a specific disposal to significantly affect the current inventory was assessed, and a judgement made on the likelihood that such a disposal could have gone unrecorded. In no case did this seem feasible.

Other issues were related to the potential for the activities of a particular type of disposal to be under- or overestimated, for example the clean materials from 'active' areas (Issue 10) and the stainless steel tanks believed to have breached disposal limits (Issue 9). As these wastes are accounted for only as part of the back-fitted inventory, data related to individual disposals are sparse. Analysis shows, however, that the impact on the radionuclide inventory of the trenches is likely to be small.

Other issues were of a more procedural nature and so, where possible, evidence has been found for the procedures or processes that were in place. For example, interviewees raised a query over the effectiveness of padlocking of the skips to prevent unknown disposals (Issue 27). However this was closely related to other issues surrounding the disposal of higher-activity, but shielded wastes. Procedures for the disposal of LLW, intermediate level waste (ILW) and alpha-waste, including laboratory wastes, were found, however, these were issued in 1980 and are not necessarily applicable to earlier or later site operations. Although staff were trained in the CfA and made aware of site procedures it does not however, prove that procedures were always followed and a level of doubt remains. Nonetheless, Health Physics undertook an extensive monitoring regime prior to transport and disposal at LLWR trenches and it would be unlikely that any regular, disposals of higher activity material would go undetected.

In summary, however, no changes are recommended to the inventory as a result of the RECALLL exercise. For all issues analysed, any impact on the current inventory would be bounded by the current uncertainties. As such, no changes to the inventory of disposals to the LLWR trenches have been recommended as an outcome of this study and assessment of the individual issues arising from the RECALL interview process did not identify any issues that would materially affect the conclusions about the environmental safety of the repository.

5 Conclusions

The 45 issues identified following review of the RECALL interviews with current or retired staff from Sellafield and/or the LLWR with operational and other relevant experience have been individually analysed. The potential impact that each issue may have on the current inventory of disposals to the trenches has been assessed via a range of methods including pursuing lines of questioning where appropriate; identifying and reviewing the available documentation; and performing scoping calculations to ascertain the significance of an issue.

The analysis of individual issues has lead to a range of conclusions. Many of the issues were concluded to have no significance for the inventory of disposals to the trenches; other issues might have caused an overestimation of the inventory whilst others might have led to an underestimation. The three categories are outlined below:

- *Issues with no impact on the inventory*

  Some issues, for example increasing Sellafield discharge limits (Issue 24) or the disposal of furnace liners in the Sellafield (B291) trenches provided background and context on the running and management of the LLWR site and/or Windscale/Sellafield, during the period of trench operations but did not directly relate to disposals to the LLWR trenches. In other cases, issues were raised regarding potential disposals to the trenches; for example the question of whether waste from the Pile 1 and Chernobyl accidents (Issues 31 and 33, respectively) had been disposed in the trenches. On further investigation, evidence was found that demonstrated that no such disposals had been made to the trenches and thus could not affect the inventory.

- *Issues with the potential to increase the inventory*

  This study has identified several issues which might have contributed to an underestimation of the current trenches inventory of key radionuclides or certain other materials (e.g. oil (Issue 11) and asbestos (Issue 36)).

  In some cases, for example the disposal of PCM from the Magazines (Issue 32) or the disposal of Trimphone dials (Issue 22), investigation demonstrated that the disposals were already accounted for in the inventory of the trenches, and that the issue did not represent a potential change to current inventory estimates.

  Other issues raised have the potential to increase the trench inventory. In some cases this is because they refer to disposals which cannot be unambiguously located in existing records, for example the disposal of Pu/Am fused salts (Issue 6) or contaminated stainless steel tanks (Issue 9). In other cases the issue related to a practice which might have led to an identified disposal having its radionuclide content underestimated, for example packaging wastes to provide additional shielding (e.g. painters handbags and lead sandwiches in Issue 5); the shielding of sacks within skips (Issue 13) or the disposal of wastes in another building's skips (Issue 27). In cases of these sorts, where documentary evidence was lacking, scoping calculations were performed to evaluate the potential effect of the issue on the inventory of the trenches. In no case was it found that the disposal practice or unrecorded disposal had the potential to materially affect the existing trench inventory.

- *Issues with the potential to reduce the inventor*y

  Other issues have been identified which would have caused an overestimation of the inventory of key radionuclides. Such issues include the disposals of non-contaminated waste from the site clearance exercises (Issue 8) and 'clean' laboratory waste (Issue 10); the potential lack of background correction when monitoring sacks of LLW (Issue 44).

  Perhaps the issue with the most potential for identifying an overestimation of the inventory raised during the RECALL issues was the already known issue of the monazite disposal (Issue 7). There is limited information available to suggest that 502 tonnes of the sand, representing some 8% of the Th-232 inventory, were actually removed from the trenches. No documentary evidence was found, however, despite extensive searches.

On balance, however, no changes are recommended to the inventory as a result of the RECALL exercise. In the case of Monazite sands, no supporting evidence was found for their removal, and the cautious approach is therefore not to modify the inventory. In the case of other issues, whilst there may be evidence for a real effect, the magnitude of the effect cannot be quantified reliably. Under these circumstances the cautious approach is to make no change to the currently assessed inventory of the trenches.

In summary, for all issues analysed, any impact of issues raised in the RECALL process on the current inventory of the trenches is likely to bounded by the current uncertainties acknowledged in the trench inventory and hence in assessments of the performance of the facility. As a result, no changes to the inventory of disposals to the LLWR trenches have been recommended in response to this study.

6 References

[1] G. Hickford and V. Smith, RECALL Interviews, Serco Report SERCO/TAS/003576.01/002, April 2011.

[2] A.S. Wareing, L. Eden, A. Jones and M. Ball. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

[3] A.J. Baker, Managing existing liabilities and future disposals at LLWR, LLWR Repository Ltd Report 10001 LLWR LTP Volume 1, Issue 01, April 2008.

[4] T.J. Sumerling, LLWR performance update for the LLWR, 10005 LLWR LTP Volume 5, Issue 01, April 2008.

[5] N. Galais and L. Fowler, LLWR Lifetime Project: Assessment of potential impacts from human intrusion and coastal erosion at the LLWR, Nexia Solutions Report 9278 Issue 3, August 2008.

[6] G.M.N. Baston, S. Magalhaes, S. Schneider and S.W. Swanton. Improvements to the Radionuclide Inventory of the LLWR. SERCO/TAS/003756/010 Issue 1, April 2011.

[7] A. Harper. ESC 2011: The disposed and forward inventory of LLWR. Serco Report SERCO/E003756/12 Issue 2, April 2011.

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Appendices

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Appendix 2	Detailed analysis of each Issue

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Appendix I
Grouping of Issues

Contents

Grouping of Issues — Breakdown by issue into relevant groups

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Group	Issue	Description
1: Unusual dispatches of materials of potential radiological significance	2	Disposal of 'Hex' cylinders, which used to contain uranium hexafluoride, into Trenches 3 and 4,.
	4	Disposal of waste arisings from clean-up in alpha plants.
	6	Disposal of plutonium and americium fused salts and/or plutonium/americium bearing liquids into Trench 2.
	7	Disposal of thorium containing ores and sands into the trenches.
	9	Disposal of redundant stainless steel tanks into Trench 2.
	16	Disposal of unirradiated natural uranium from the laboratories.
	17	Disposal of alpha and beta contaminated source trays in the trenches.
	37	Disposal of luminous dials such as watches and navigation equipment from the Ministry of Defence (MoD).
	41	Recollection of the disposal of a sludge tank that had been shown to have 'high' activity readings.
	43	Disposal of Springfield drums which may contain uranium residues.
	45	Disposal of unwashed uranium and plutonium contaminated glass vials from the laboratories.
2: Disposal of materials of non-radiological significance	8	Disposal of loose sacks from general site clean-up.
	11	Disposal of various items of machinery in the trenches; a bus, flatbed truck or trailer, car and a drott (brand name of manufacturer caterpillar tractor and low loader type trailer equipment) which is half-way down Trench 5. Disposal of liquids (includes petrol & diesel), oils and greases in the trenches and use of second-hand solvent/oil drums prior to 1972.
3: Disposal of materials of very low/negligible activity	10	That a significant proportion of the material disposed of in the trenches was 'clean'. The RSA authorisation states that any liquid or solid wastes arising in an 'active' area are deemed to be contaminated.
	12	Disposal of excavated materials, in particular soil, from the construction and decommissioning of buildings.
	15	Disposal of plastic gloves to the LLWR trenches.
4: Disposal of material of potentially high radionuclide inventory	3	Disposal of waste into another buildings' skip without the knowledge of the building consignors.
	5	Lead sandwiches, painter's handbags and other methods used to provide a level of shielding for laboratory waste.
	13	Use of 'averaging' to shield higher activity wastes.
	27	Locking of skips with padlocks; some questions remain as to when this was introduced, who had access to the keys, whether a single key could open all the padlocks and why padlocks went missing.
	30	Was any 'higher' activity waste generated from incidents such as the Pile 1 fire disposed of in the LLWR trenches?
	38	Generation and disposal of high activity materials from Sellafield buildings known to contain a lot of activity e.g. B30.
	39	Storage of 'Seal' sands in Trench 7 prior to disposal in Vault 8.
5: Identification of potentially inappropriate disposals	1	Erroneous disposal of plutonium contaminated materials (PCM) drums into the trenches.
	14	During excavation of the eastern wall of Vault 8, Trench 3 was disturbed. Two items of waste were exposed and found to be above Drigg limits.
	22	Erroneous disposal of Trimphones (type of phone popular in the 1970's) from Harwell.

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Group	Issue	Description
	31	Greenpeace activists broke into LLWR and took pictures of the trenches and in particular a glovebox in the open Trench 7.
	32	A quantity of carbon-14 was disposed in the trenches in error.
	33	The question of whether any waste from the Chernobyl incident was imported to the UK and tipped into the trenches was raised.
	42	During the routine monitoring at the skip handling facility at the edge of separation area, three bags of bird guano were found to be above Drigg limits and removed from the skip.
	36	Disposal of asbestos in the trenches.
6: Quality of measurements	34	Each building now generates a waste fingerprint on which the inventory is based. Over time this may change as the plant operations change.
	35	Site clearance team (involved in site clear-up, see Issue 8) were not always fully appraised of the CfA.
	44	The sacks of LLW were monitored outside the building of origin and it is unclear whether a background correction was applied.
7: Issues not relating to disposals at LLWR	18	Changing of floc in the liquid effluent treatment plant (LETP) was irregular and may have allowed waste solvents to go out to sea.
	19	There were a number of trench fires over the operating life of the trenches.
	20	The practice of leaving the trenches uncovered overnight meant that waste was being blown about the local area.
	21	Removal of tools from LLWR trenches after they had been sent for disposal.
	23	Storage of PCM waste on the LLWR site. Includes painter's handbags full of glass vials, drums of waste and gloveboxes.
	24	Increasing authorisation limits for Sellafield.
	25	Radiation measurements taken at the magazines during the course of retrievals may have been higher than quoted to the Drigg Parish Council.
	26	Approximately 4,500 drums were removed from Trench 7 once the waste monitoring and compaction facility (WAMAC) at Sellafield opened. Having been stored for a number of years, some drums had corroded and leaked.
	28	Identification of useful documents and earlier relevant studies or investigations.
	29	Disposal of furnace liners (classed as ILW) in the Sellafield trenches (B291).
	40	Leachate from the trenches was regularly monitored and could provide evidence of the introduction of a particular waste stream.

Appendix 2
Detailed analysis of Issues

Contents

Detailed analysis of each issue raised during the RECALL programme.

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Issue Number: 1

Description of Issue:
Erroneous disposal of plutonium contaminated materials (PCM) drums into the trenches.

Potential Significance to the Inventory:
The total Pu inventory could be under-estimated if a significant disposal of PCM was unrecorded.

Analysis:
The interviewee did not originally mention a time or location of this erroneous disposal, but in further discussion suggested that the disposal occurred around 1983-1984 [1]. Although the inventory includes the disposal of PCM drums from the magazines in Trench 2 during 1968 and 1971, there is no reference to any similar disposals on a timeframe consistent with that referred to by the interviewee [2, 3].

If the disposal was erroneous, it is probable that an investigation was carried out, following which the material would either have been removed or permitted to stay in the trenches. Even if the original disposal was erroneous, it does not necessarily imply that it was not recorded. Attempts to identify an incident report for this disposal have been unsuccessful.

The aforementioned disposal of PCM to Trench 2 accounted for approximately 10% of the total Pu inventory. For the erroneous disposal referred to in this issue to be of any significance, it would have to be at least half as active as this. It does not, however, seem feasible that such a large (and active) disposal could have occurred in error and remain unrecorded or unaccounted for.

References:

[1] Personal communications, interviewee and EBM Strategic Consulting. February 2010.

[2] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

[2] C.P. Lennon, A. Jones, L. Eden and M. Ball. LLWR Lifetime Plan: Heterogeneity of the Inventory of Past and Potential Future Disposals at the LLWR. Nexia Solutions Report (07) 9126 Issue 03, 2008.

Conclusions:
Even if the original disposal was inappropriate, it does not necessarily imply that the disposal went unrecorded. It does not seem feasible that a disposal large enough to account for 5% of the current Pu inventory could have occurred in error and remain unrecorded or unaccounted for. In the absence of further information, no changes to the inventory can be recommended.

Any Related Issues:
None.

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Issue Number: 2

Description of Issue:
Disposal of redundant uranium hexafluoride ('Hex') cylinders, into Trench 3.

(Interviewee stated that there were '680 cylinders (1m x 2m) with ~1 kg residue in each. Nuclear Installations Inspectorate (NII) gave clearance for disposal into Trench 3 and covered with tons of lime and sanded before being covered by other waste'.)

Potential Significance to the Inventory:
This is potentially significant to the inventory if the disposals are unrecorded, on the basis of analyses undertaken for the Requirement 2 submission to the Environment Agency in 2008 [1, 2, 3] the U-234 and U-238 are expected to have a significant effect upon the 2011 ESC.

Analysis:
The disposal of uranium hexafluoride cylinders is recognised in the 2002 Post Closure Safety Case (PCSC). Reference 4 reports that '…697 cylinders with a total volume of approximately 630 m^3 were disposed to Trench 3 in 1977. The cylinders contained trace amounts of uranium hexafluoride residue, but were otherwise empty. The cylinders were emplaced in an upright manner on the floor of the trench then covered in lime and a layer of soil 1 m in depth before normal operations were continued on top of the soil.'

However, the cylinders are mentioned in the PCSC [4] in the context of the potential need for further assessment of the safety implications associated with the voidage within the cylinders and the potential for release of hydrogen fluoride (HF). The cylinders were not accounted for in the inventory as a specific disposal, as their residual activities were not deemed to be significant [5].

The original assessment performed by Wareing [6] was based on information from reference 7. Review of this document shows that the vessels originally held UF_6 withdrawn from the plant at enrichment values of 0.4 – 0.45% U-235, i.e. depleted uranium (DU). A residual content of 0.25 – 2 kg UF_6 per cylinder was deemed to be likely. Using these values, scoping calculations show that the residual uranium within the cylinders amount to between 0.01 – 0.2 % of the current inventory of the trenches for the different radioisotopes. As such, their omittance as a 'key' consignment within the inventory is not a concern. These calculations were based on the maximum quantity of U likely to be present in the cylinders, and so the actual activities are likely to be lower than estimated.

Examination of the D4 records of disposal for these cylinders revealed that the radioisotope content of the cylinders was not recorded at the time of disposal [8]. In the event that the cylinders had been used to store reprocessed UF_6 it would be necessary to consider the quantity of Tc-99, the most significant by-product of U-235 fission, likely to remain associated with the uranium residues. However, reference 6 offers no reason to suggest that the cylinders had been used to store reprocessed UF_6 and so there is no indication that Tc-99 should be considered in the scoping calculations.

References:

[1] A.J. Baker, Managing existing liabilities and future disposals at LLWR, LLWR Repository Ltd Report 10001 LLWR LTP Volume 1, Issue 01, 30 April 2008.

[2] T.J. Sumerling, LLWR performance update for the LLWR, LLWR Repository Ltd Report

10005 LLWR LTP Volume 5, Issue 01, 30 April 2008.

[3] N. Galais and L. Fowler, LLWR Lifetime Project: Assessment of potential impacts from human intrusion and coastal erosion at the LLWR, Nexia Solutions Report 9278 Issue 3, August 2008.

[4] BNFL, Drigg Post-Closure Safety Case: Overview Report, 2002.

[5] A.S. Wareing. Personal communications. February 2010.

[6] A.S. Wareing. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions (07) 9124 Issue 3, 2008.

[7] J.A. Coote and J.K. Donoghue. Safety Assessment of the Storage of "Hex Cylinders" on the Drigg Site and of the Potential Hazards Associated with their Transport to Springfields. Safety Assessment Group, BNFL, Windscale. HCSC/(76)/P6 May 1976.

[8] D4 records of disposal, numbers 2402-2416, Iron Mountain archive reference 1706.

Conclusions:

This authorised disposal of 'Hex' cylinders was considered for inclusion in the inventory as a specific disposal, but this was not done as the inventory of radionuclides was not assessed as significant. Scoping calculations show that the maximum amount of U contained within the cylinders would be comparable to only 0.01 – 0.2 % of the current inventory and therefore the cylinders do not warrant inclusion as a 'key' disposal.

There is no evidence to suggest that the cylinders contained reprocessed UF_6 and thus there would is no justification for considering a contribution to the Tc-99 inventory from this disposal.

Any Related Issues:

Issue 43 deals with Springfields drummed Uranium waste.

Issue Number: 3

Description of Issue:
Disposal of waste into another building's skip without the knowledge of the building consignors.

Potential Significance to the Inventory:
This issue was raised by a number of the interviewees. It could have impact on the inventory, as the material might be accounted for in the inventory with an inappropriate fingerprint.

Analysis:
Disposing of wastes in this way would be a clear breach of waste management procedures for the Sellafield site, with potentially serious consequences for the individual involved. It therefore seems most unlikely that this practice would have occurred with any regularity.

Any significant disposals of this sort, particularly if they were of higher activity wastes, would have been detected through the regular monitoring programme by Health Physics prior to disposal at LLWR, as demonstrated by Issue 42. As an extra precaution, Sellafield introduced lockable skips in 1973 which should have prevented these kinds of disposals. Some interviewees questioned the effectiveness of this measure, since the location of the keys was common knowledge. Attempts to find documentation relating to the introduction of these new skips has been unsuccessful (see Issue 27). However, locking of the skips would have prevented random disposal of waste, since the locked skips would have made this practice more difficult. As such, any disposal by unauthorised personnel would have been a deliberate act and on this basis is not likely to have occurred very often since the risk of being discovered was greater.

Conclusions:
No specific incidences of this practice have been officially reported and whilst some of the interviewees knew of personnel that had done this, others did not have first-hand knowledge of such behaviour. This indicates that it is likely only a very small proportion of the workforce were ever involved with such practices. In addition, it is unlikely, considering the potential impact on the employee and the regular monitoring by Health Physics that this practice would have occurred with any regularity. On this basis, it can be concluded that this issue would not materially affect the inventory.

Any Related Issues:
Issues 13 and 27.

Issue Number: 4

Description of Issue:
Disposal of waste arisings from clean-up in alpha plants.

Potential Significance to the Inventory:
The inventory may be underestimated if there have been unrecorded disposals of high activity, especially if it occurred on a regular basis.

Analysis:
No reference is given to the nature of the disposals and no specific disposals are described. There is no indication that the interviewee is referring to unrecorded disposals or any which are above the disposal limits.

Although no timeframe is referred to by the interviewee, there have been long-standing procedures in place for separating highly active and low-level wastes arising from within alpha plants. For example, in the 1980 Health and Safety Regulations [1], the instruction for the disposal of waste arising from cleaning up spillages within alpha plants was that it should be treated as highly active waste unless it has been decontaminated or monitoring has shown that the level of contamination is below the defining limit for higher activity wastes. If designated ‘highly active waste’, then it would be prepared for storage as PCM, rather than disposed in the trenches at LLWR, and thus would not be included in the trenches’ inventory. If disposed of as low activity waste, then such disposals would be accounted for as part of the building’s waste fingerprint.

Reference:

[1] Health and Safety Regulations. Administration and Legal Control Section. Disposal of Solid Alpha Active Waste Arising on the Windscale and Calder Site. HSR A 10 (5). Issued July 1980.

Conclusions:
There is no basis for assuming the interviewee was referring to either unrecorded or unauthorised disposals and as the buildings operated with a waste fingerprint then this type of waste would have been accounted for as part of a normal procedure and, thus, are included in the inventory as backfitted ‘routine consignments’.

Any Related Issues:
Issues 5, 10, 15, 34 and 38.

Issue Number: 5

Description of Issue:
The disposal of lead sandwiches, painter's handbags and other methods used to provide a level of shielding for higher activity wastes into building LLW skips.

Potential Significance to the Inventory:
This Issue was raised by a number of the interviewees. The impact on the inventory of LLWR trenches depends on the fate of these materials.

- It is possible that these materials were disposed of to the trenches. In this case, the trench inventories are likely to be understated to some extent, if the disposals were not recorded.
- Some higher activity wastes (ILW) were transferred to the LLWR site for storage in the magazines [1]. The magazines have subsequently been emptied and the materials removed from the site, to allow the wastes to be appropriately treated and stored for final disposal when a facility becomes available. Materials following this route will clearly have no effect on the inventory of LLWR.

Reference:

[1] BNFL, Drigg Post-Closure Safety Case, 2002, September 2002.

Analysis:
During the course of the RECALL interviews, it became apparent that these methods of disposal, particularly the painter's tins, were widely used for both LLW and ILW waste streams, and the necessary containers were readily available from site stores. However, interviewees noted that there were a variety of materials used to pack the waste, including lead shot, concrete and paper towels. Some, but not all, of the packing materials would have afforded shielding of the tins' activity content; however, the paint tins were used for both LLW and higher activity wastes, including alpha bearing materials. Review of a selection of LLWR disposal records shows that 'paint tins' were often listed amongst the different waste forms. Use of the paint tins seems therefore to have been an established method of disposal and was endorsed by laboratory management and Health Physics personnel.

All waste was segregated at source according to the levels of activity and each plant was aware of the expected activity levels of their wastes and would have had a suitable disposal route identified. Therefore, it is unlikely that there would be many occasions on which an unexpected higher activity waste would be generated. Disposal of small one-off wastes to ILW storage silos may not have been as readily accessible as for routine disposals and therefore it is possible that occasionally it is these types of waste that would be candidates for shielding and consigning as LLW. However, methods of shielding such as wrapping in lead would be a deliberate act with potentially serious consequences. As such, there would have been limited incentive to dispose of higher activity wastes in this manner. Health Physics routine monitoring did sometimes identify disposals in breach of the CfA (see Issue 42) so this would have served as a deterrent if the disposal practices described here were unauthorised.

Alternatively, it is possible that those generating these higher activity wastes were not fully aware of the disposal routes and incorrectly thought that they went to LLWR when in they were actually dealt with by the correct procedures.

However, the described methods of shielding would likely only be used for higher-activity

beta/gamma wastes which would have included short-lived radionuclides such as Sr-90, Cs-137 and Co-60. As none of these are key radionuclides and all are known to be present in large amounts in the trenches it is not believed that such disposals could significantly perturb the current inventory.
<u>Conclusions</u>: It is thought likely that the described methods of packaging could have been used to shield higher-activity beta/gamma wastes, which would include short-lived radionuclides such as Sr-90, Cs-137 and Co-60, already known to be present in high quantities in the trenches. It is likely that the wastes would have been generated as occasional one-off waste forms and that the 'illegal' disposal of these materials into the skips would not have occurred with any regulatory, as the monitoring by Health Physics personnel would have detected such items. As it is thought that these methods of disposal were not conducted with any regularity and were likely to contain radionuclides that are not 'key', already present in the trenches, then it is unlikely that that such disposals could significantly perturb the current inventory.
Any Related Issues: Issues 3, 13 and 27.

Issue Number: 6

Description of Issue:
Disposal of plutonium and americium fused salts and/or plutonium and americium bearing liquids into Trench 2 (30 2.5 l Winchester flasks wrapped in lead from B229 laboratories pre-1971).

Potential Significance to the Inventory:
The total Pu and Am inventories could be underestimated if these disposals are unaccounted for.

Analysis:
Inventory documentation [1, 2] shows the most concentrated Pu disposals to be located in Trench 2 (which also contains PCM drums from the magazines) and in Trench 4. Am-242m is located mostly in Trenches 2, 6 and 7, whilst Am-241 is mostly in Trenches 3 and 7.

Some of the Trench 2 and Trench 3 inventories, because of the timings, could possibly account for the fused salts although they are not mentioned as a key waste-stream [1, 2] and it was not possible to identify the particular disposals in the Inventory [3].

Attempts were made to trace this disposal through examination of the D4 disposal records, safety case notes and the Internal Transfer Notes from the corresponding time period, but it was not possible to obtain the relevant records.

In the absence of any further information, scoping calculations were performed to assess the potential significance of this issue. In order to contribute 5% of the current trenches inventory, this particular disposal would need an activity of 10 to 750 GBq for the various Pu isotopes and 30 GBq of Am-241. It is important to note that this waste would have been contactable, i.e. somebody would have monitored it and carried it from the laboratory and therefore this is not a credible scenario. The unshielded dose from the total 30 GBq Am-241 disposal would account for ~10% of a worker's annual limit and even allowing for a 1 cm layer of lead shielding, the intensity would only be reduced by 4%. The dose to workers from a disposal with this activity would therefore be unreasonably high and the removal of the flasks from laboratories would likely trigger various alarms. As such, a disposal with activity levels sufficient to significantly alter the inventory is deemed unlikely to have occurred. Any lesser contribution would be of insignificant consequence and thus, with no further information/evidence, this disposal is not deemed to affect the current trenches inventory.

References:

[1] C.P. Lennon, A. Jones, L. Eden and M. Ball. LLWR Lifetime Plan: Heterogeneity of the Inventory of Past and Potential Future Disposals at the LLWR. Nexia Solutions Report (07) 9126 Issue 03, 2008.

[2] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

[3] Inventory spreadsheets associated with NNL Trench Inventory Reports 9124 and 9126.

Conclusions:
No evidence relating to the specific disposal was identified, but that does not necessarily

mean it is unrecorded or unaccounted for in the inventory. Attempts to trace this disposal through examination of D4's from the appropriate time period were unsuccessful. However, scoping calculations have demonstrated that in the event of a disposal of the nature described by the interviewee it would be unlikely to contain sufficient activity to significantly affect the inventory. For this to be the case, the doses arising from the material could not reasonably have gone undetected.
Any Related Issues: None.

Issue Number: 7

Description of Issue:
Disposal of thorium containing ores and sands into the trenches

Potential Significance to the Inventory:
Could affect the total thorium (Th) inventory if disposals are not accurately recorded

Analysis:
The spatial distribution of the total of 1.28 TBq of Th-232 across the LLWR trenches is described in Lennon et al. [1]. Whilst there is a reasonable amount of activity distributed across Trenches 4 and 5, there are a small number of bays (1 and 2 and 76 to 80) in Trench 2 that contain between 1 and 10% of the total Th-232 activity. Wareing [2] highlights the four main sources of Th-232 in the inventory as those arising from Steetley chemicals (56.5%), thorite sand (23.2%), monazite sand (10.4%) and Thorium Ltd (2.3%), each described in brief below.

Steetley Chemicals:
A significant component of the thorium inventory is from disposals of thorium-contaminated waste from Steetley Chemicals Ltd and described as being rare earth hydrates. These disposals occurred to Trenches 4, 5 and 6 during the period 1979 to 1983.

Thorium Ltd:
Disposals of thorium-contaminated waste from Thorium Ltd occurred during two separate time periods, 1965 to 1967 and 1973 to 1977: the waste was in the form of filter press-cake. Wareing [2] interpreted the declaration on the disposal form of an Ra-226 (daughter to the parent nuclide U-238) component of the waste to imply that the source material was thorite sand, as this is the only mineral ore containing identifiable quantities of U-238, which is used in the commercial production of thorium. (N.B. The alternative commercial ore, monazite sand, contains negligible amounts of uranium.)

Thorite-sands:
Wareing [2] describes the use of various parts of the LLWR site for the storage, and later for the disposal, of thorite sands (ThO_2SiO_4). In the period before 1963, thorite sands were stored in the magazines. In 1963, the material was removed from the magazines to Dalton-in-Furness. Routine reports and returns for the site describe these activities. In the period 1972 to 1973, the materials were returned to LLWR for final disposal in Trench 2.

Monazite-sands:
Wareing [2] also discusses the disposal of monazite sands to Trench 2 in 1960 from two consigners: 229 t were disposed from Greenwich by Metropolitan Storage & Trading Co. Ltd and a further 467 t from MOS Depot Leyland and the MoS establishment at Burnley. Whilst disposal records for monazite sands do not exist, Wareing [2] was able to calculate an inventory based on weight and volume data from transport receipts, the concentration of Th-232 in the material, and the assumption of secular equilibrium between Th-232 and its daughters Th-238 and Ra-228.

However, public records investigated by Lennon [3] implied that some 502 tonnes of the 709 tonnes monazite sands originally present were actually removed from Trench 2 at a later date. Attempts to corroborate this statement failed and so the full amount was accounted for in the inventory, in the interests of producing a conservative inventory [4].

The potential effect of removing this material on the overall inventory of the trenches can be estimated in the following way. The total monazite sands in the inventory (709 t) comprise 10.4% of the total Th-232 inventory of the trenches (1.38 TBq). Removal of 502 t of monazite sand therefore reduces the total Th-232 inventory by about 8%. The assumption that the material remains in the trenches therefore represents a modest potential conservatism in the overall estimate of Th-232 activity.

References:

[1] C.P. Lennon, A. Jones, L. Eden and M. Ball. LLWR Lifetime Plan: Heterogeneity of the Inventory of Past and Potential Future Disposals at the LLWR. Nexia Solutions Report (07) 9126 Issue 03, 2008.

[2] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

[3] C.P. Lennon. LLWR Lifetime Project: Phase 1 Mapping and Quantification of Key Radionuclides in the Disposal Trenches at the LLWR. Nexia Solutions 8166. QRS-1356A-Ni1. Issue 3. 2007.

[4] A.S. Wareing. Personal communications. February 2010.

Conclusions:

Wareing's [2] inventory of the thorite sands appears to be thorough, having consulted month-end reports, period-end returns and disposal records and so no further work is required on this subject. It is also considered unlikely that any improvement can be made to the inventory arising from the disposals from Steetley Chemicals or Thorite Ltd.

The only issue that would affect the Th inventory of the trenches is whether the 502 t of monazite was definitely removed from the trenches. However, attempts to identify evidence to further elucidate this issue were unsuccessful and so it is recommended that it remains accounted for in the inventory, representing a modest potential conservatism in the Th inventory.

Any Related Issues:

None.

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<u>Issue Number</u>: 8

<u>Description of Issue:</u>
Disposal of loose sacks from general site clean-up.

<u>Potential Significance to the Inventory</u>:
This issue may have significance for the inventory if there were unrecorded disposals of high activity or overestimates of activity from relatively uncontaminated materials.

<u>Analysis</u>:
In the 1970's the Sellafield house-keeping rules changed and the site operative team collected general waste (loose sacks around the site including outside the skips, other items such as building fixtures and fittings) from around separation area, but reportedly also helped to remove some of the more 'difficult' low-level waste (pipework, scrap metal and large objects) that needed to be cut up and sent it to LLWR for disposal. The level of contamination of these wastes is unclear, but it is unlikely that these wastes were heavily contaminated if they were recovered from open areas of site. Reference to larger items, such as doors, implies it was not routine laboratory-wastes in this issue.

Evidence for the disposal of miscellaneous items and sacks from site clearance procedures can be found in the archived D4 records, with the highest measured dose rate recorded on the form [1]. In addition to the monitoring of individual items, the skip in which they were disposed would have been monitored by Health Physics staff prior to despatch to LLWR. As such, it is unlikely that regular, high-level disposals would have gone unnoticed.

It is important to note that the trenches inventory does not include specific data for every disposal, but has captured disposal records data for key consignments only [2, 3]. The inventory for any remaining pre-1993 disposals (i.e. those deemed to be less significant and referred to as 'routine consignments') are based on a back-fitting method applying detailed radionuclide and material inventory data from contemporary waste streams to known historical disposal volumes by consignor. If a building fingerprint was used for a whole skip containing relatively uncontaminated materials, it might be inferred that the inventory of those materials was overestimated, but this is not thought to be significant enough to warrant a change to the inventory.

References:

[1] D4 records from Iron Mountain archives. Selection of D4's from the 1970's were checked.

[2] BNFL, Drigg Post-Closure Safety Case 2002, September 2002.

[3] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

Conclusions: Evidence has been found in the archived D4s that miscellaneous items were recorded in a manner consistent with that used for routine, laboratory disposals, potentially leading to an overestimate of the radionuclide inventory. There is no basis for assuming the interviewee was referring to disposals above the LLWR acceptance levels and where these consignments are not considered to be 'key' they will be accounted for in the inventory via back-fitting. This could potentially lead to a conservative inventory estimate, but this is not thought to be significant enough to warrant a change to the inventory.
Any Related Issues: Issues 10 and 34.

<u>Issue Number</u>: 9

<u>Description of Issue:</u>
Disposal of redundant stainless steel tanks 'full of contaminated liquor' into Trench 2 (12-15 tanks of 8-10,000 L volume).

<u>Potential Significance to the Inventory</u>:
The inventory could be under-estimated if the disposals were unrecorded or the level of contamination was under-reported.

<u>Analysis</u>:
No specific disposal date was mentioned by the interviewee, but the tanks were stored *in-situ* in Trench 1 before they were believed to have been placed in Trench 2. As Trench 2 opened in 1973, it must have occurred shortly afterwards, while Trench 1 was still open. The interviewee stated that the tanks were 'full of water contaminated liquor' (which presumably means they were contaminated and partially filled with rainwater) and that swabs showed levels of alpha contamination above the disposal limits at the time. However, this does not necessarily imply that they were unrecorded.

If recorded, however, it is possible that they were under-reported. Prior to the 1988 revised authorisation under RSA 60, the dose was measured as a function of the volume of waste. The use of shielding to 'average' out the dose over the volume of waste could possibly have been practiced to reduce the detectable dose rate, see Issue 13.

Although stainless steel is quantified and mapped in Trench 2 [1], no evidence for these specific tanks could be found in the inventory spreadsheets [2] and so their inclusion in the inventory is indirect, i.e. as part of the back-fitted pre-1993 inventory. Even if the surface levels were higher than the disposal limits at the time, it is important to bear in mind that the waste was still contact handleable – the items had been left in the open, exposing anyone who handled it, so it is unlikely that the contamination levels would be high enough to warrant inclusion of the tanks in the inventory as a specific disposal. As these wastes are accounted for only as part of the back-fitted 'routine consignments' fraction of the inventory, there is no net quantifiable impact from an underestimation of the levels of contamination.

References:

[1] C.P. Lennon, A. Jones, L. Eden and M. Ball. LLWR Lifetime Plan: Heterogeneity of the Inventory of Past and Potential Future Disposals at the LLWR. Nexia Solutions Report (07) 9126 Issue 03, 2008.

[2] Inventory spreadsheets associated with NNL Trench Inventory Reports 9124 and 9126.

<u>Conclusions</u>:
No evidence for these specific disposals could be found in the inventory, but this does not necessarily imply that they were unrecorded. However, if recorded it is possible that they were under-reported or the waste was 'averaged' if swabs had previously determined that activity levels were too high for legitimate trench disposal. As these wastes are accounted for as part of the back-fitted inventory, there is no net quantifiable impact from an underestimation of the levels of contamination. In the absence of further information, these disposals cannot be considered for inclusion as key consignments within the inventory.

Any Related Issues: Issue 13 (averaging).

serco

Issue Number: 10

Description of Issue:
A significant proportion of the material disposed of in the trenches was 'clean'. Any liquid or solid wastes arising in an 'active' area are deemed to be contaminated and are disposed of as such.

Potential Significance to the Inventory:
Depending how the activity was recorded on the disposals records and how this information was transferred to the inventory, there may be a significant effect on the inventory. If the activity of disposals was taken as being at the limit of detection when it was, in reality, much lower, then the inventory arising from these disposals could be significantly over-estimated.

Analysis:
The issue of the disposal of 'clean' material into the trenches at LLWR may have arisen via two routes. The first is that according to one interviewee any materials that entered the separation area were classed as LLW as a matter of precaution, regardless of any dose data. A second factor for consideration is that, until the late 1980's, the cost of disposal at LLWR was lower than municipal waste routes and so may have been viewed as an easy option for the disposal of non-contaminated, general waste.

It is also important to note that the trenches inventory does not include data for every disposal, but has captured disposal records data for key consignments only [1, 2]. The inventory for any remaining pre-1993 disposals (i.e. those deemed to be less significant and referred to as 'routine consignments') are based on a back-fitting method applying detailed radionuclide and material inventory data from contemporary waste streams to known historical disposal volumes by consignor. As such, consignments of 'clean' material are unlikely to be directly accounted for, but will be included as part of the inventory derived through back-fitting thus resulting in an overestimate of the activity disposed of to the trenches. However, any overestimation would be difficult to quantify accurately, but is believed to be within the uncertainty bounds of the current inventory.

References:

[1] BNFL, Drigg Post-Closure Safety Case, 2002, September 2002.

[2] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

[3] A. Harper. ESC 2011: The disposed and forward inventory of LLW. SERCO/E003756/12 Issue 2

Conclusions:
The 'clean' waste was likely accounted for at the time of disposal as a part of the building's fingerprint and where these consignments are not considered to be 'key' they will be accounted for in the inventory via back-fitting. It would be difficult to quantify this conservative effect, but it is believed to be bounded by the current inventory uncertainties.

Any Related Issues:
None.

serco

Issue Number: 11

Description of Issue:
Disposal of various items of machinery in the trenches and flammable organic liquids such as petrol, diesel, oils, and greases. Includes the use of secondhand drums containing solvent or oil residues up until 1972.

Potential Significance to the Inventory:
Disposals of organic materials are recorded in the current inventory. However, interviewees have suggested that drums contaminated with oils and greases were disposed of to LLWR. In addition, machinery potentially containing hydraulic fluids, lubricants or fuel may have been disposed of to the trenches. It is not clear that the organic component of these disposals would have been properly assessed.

Analysis:
There are two aspects to this issue. The first is the potential impact that the disposal of large items of machinery might have on the organic inventory if the organic fluids have not been drained. The second is a more general issue in that there were drums of organic, flammable liquids disposed of in the trenches.

Oil has been recorded in the inventory with a total volume of 1088 m^3. Most oil can be found in Trench 2 (16.4%), Trench 3 (19.4%) and Trench 7 (25.5%), with over half of the volume being present in less than 10% of the trench disposal areas [1]. One percent of the total known inventory of oil in the trenches is equivalent to 10,880 l. Based on the interviews given during the RECALL programme, the number of items of machinery tipped into the trenches is estimated to be no greater than five. However, even allowing for a far greater number of disposed vehicles and using the conservative assumption that none had any oil drained prior to disposal, it is not credible that sufficient oil to increase the overall inventory by 1% could have been introduced to the trenches via this route. It can therefore be concluded that the disposal of machinery would have no significant impact on the current inventory of oil in the trenches.

The breakdown of materials in the inventory as described in [1] includes, Other Organics (3440 m^3) and Unknown Organics (1090 m^3) and it is not clear which category includes the disposal of fuel such as petrol and diesel or lubricants and grease. A similar line of argument to that deployed in the case of oil shows that even if the organics inventory of disposed machinery is not accounted for, its inclusion would not materially affect the overall inventory of the trenches.

References:

[1] C.P. Lennon, A. Jones, L. Eden and M. Ball. LLWR Lifetime Plan: Heterogeneity of the Inventory of Past and Potential Future Disposals at the LLWR. Nexia Solutions Report (07) 9126 Issue 03, 2008.

Conclusions:
Organic and flammable liquids have been accounted for in the current inventory. Scoping calculations have demonstrated that the disposal of large items of machinery could not credibly have introduced a volume of oil sufficient to perturb the current inventory.

Any Related Issues:
None.

Issue Number: 12

Description of Issue:
Disposal of excavated materials, in particular soil from the construction and decommissioning of buildings.

Potential Significance to the Inventory:
Contaminated soil from separation area could contain a number of key radionuclides from building or pipework leaks, whether from the remains of an old building or for the foundations of a new one. Any soil from excavation works (sampling boreholes) or soil removed from mounds created during decommissioning and/or construction work was tested to ascertain whether it could be assigned as LLW or very low level waste (VLLW). Any VLLW was sent to the South Tip rather than to LLWR.

Analysis:
Lennon *et al* [1] note that the trench maps and radionuclide inventories of disposed soil are based on an understanding of the distribution of the materials based on the fingerprints of analogous waste streams in the current UKRWI, rather than the direct analysis of disposal records [1]. This is probably the only feasible approach, but its effectiveness depends upon a good match for waste streams.

The distribution of disposed soil in the trenches is heterogeneous due to large volumes consigned during the period 1979 to 1983 as a result of increased construction and decommissioning activities across the Sellafield site. The waste stream 2D54 from the 1991 National Inventory has provided the basis for the disposals over this time period [2].

The total volume of soil sent to the trenches is 71,960 m^3, most of which can be found in Trench 4 (58.4%) and Trench 5 (16.9%), with over half of the volume being present in less than 10% of the trench disposal areas [1].

References:

[1] C.P. Lennon, A. Jones, L. Eden and M. Ball. LLWR Lifetime Plan: Heterogeneity of the Inventory of Past and Potential Future Disposals at the LLWR. Nexia Solutions Report (07) 9126 Issue 03, 2008.

[2] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

Conclusions:
The volume of soil in the trenches has been reviewed and developed as part of the current inventory. There is no reason to question that these records fully account for the soil consigned to LLWR.

Any Related Issues:
None.

<u>Issue Number</u>: 13

<u>Description of Issue:</u>
Use of 'averaging' to shield higher activity waste across the volume of material in a skip.

<u>Potential Significance to the Inventory</u>:
This may result in an underestimation of the inventory of some radionuclides the measured external gamma dose was reduced.

<u>Analysis</u>:
Before 1988, skip inventories were determined by measuring the external gamma dose and using an assumed fingerprint to calculate the inventory from these data. If the positioning of an item within a skip was such as to artificially reduce the dose measurements, the inventory of the skip would be underestimated.

An important aspect of this issue is related to the ease of disposal for higher activity waste. If there is an accessible disposal route, then there would be no motivation to risk investigation by inappropriate disposal in a LLW skip. However, the Health and Safety regulation, A9, issued in July 1980 [1] notes that for medium and high beta/gamma waste; 'Space for storage of such waste on site is limited' and that it is the responsibility of originators to 'minimise arisings'. This could have been interpreted in such a way that meant it was easier to shield any 'one-off' waste that was slightly above LLWR disposal limits, rather than go through the process of consigning it as ILW. It is highly likely that if this practice took place, it would have done so for 'one-off' disposals only, and therefore would not have been with any regularity. Any routinely generated ILW waste would have had an established disposal route as ILW and there would have been no reason to conceal in a LLW skip.

However, as for Issue 5, this method of shielding would only have been used for beta/gamma wastes (of which there are known high quantities in the trenches) and the additional shielding from the surrounding, low-density wastes is probably less effective than the shielding provided by the metal skip itself. Therefore, the impact on the measured dose rate and the subsequent inventory calculations is likely to be negligible.

Reference:

[1] Safety in Research and Development Department – Regulations

<u>Conclusions</u>:
This method of shielding waste with higher-activity wastes would have been used for beta/gamma wastes, containing radionuclides already known to be present in high quantities in the trenches. The level of shielding offered by this method is not likely to have had much impact on the measured dose rates and therefore the impact on the measured dose rate and the subsequent inventory calculations is likely to be low.
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Any Related Issues:
Issues 3, 5 and 27.

<u>Issue Number</u>: 14

<u>Description of Issue:</u>
During the excavation of the eastern wall of Vault 8, Trench 3 was disturbed. Two items of highly active waste were thought to have been exposed.

<u>Potential Significance to the Inventory</u>:
The incident itself would not affect the inventory unless the items had activity levels above those permitted for disposal at LLWR and/or were unrecorded or incorrectly recorded at the time of disposal.

<u>Analysis</u>:
An investigation into the incident was performed at the time and the items were not disposals of spent fuel in breach of the LLWR CfA as first thought, but unirradiated uranium breeder pellets from UKAEA's fast reactor programme [1]. The pellets were reportedly contaminated with plutonium from previously being handled within a glovebox. A report presented to the Sellafield Board of Inquiry is reported to have arrived at the conclusion that the activities were insignificant compared with the total trench inventory of uranium [2]. Attempts to trace this report for review have been unsuccessful.

References:

[1] R. Chilton. Personal Communication with Richard Cummings, February 2010.

[2] P. Grimwood. Personal Communication with Richard Cummings, November 2009.

<u>Conclusions</u>:
The incident was investigated at the time and was not concluded to affect the inventory of uranium within the trenches. Attempts to trace the record of the investigation for review have been unsuccessful.

Any Related Issues:
Potentially related to Issues 5 and 13.

Issue Number: 15

Description of Issue:
Disposal of plastic gloves to the LLWR trenches.

Potential Significance to the Inventory:
The disposable plastic gloves were used extensively across site, especially in the laboratories, and were thought to be one of the most common waste forms consigned to LLWR. However, it was noted in the interviews that the gloves from the laboratories would be disposed of without any washing regardless of what levels of contamination they may have. This indicates that they could be a source of radionuclides and, if unaccounted for, could potentially have an impact on the inventory.

It should be noted that on a practical level, the washing of all contaminated gloves does not necessarily represent best practice as it would create more liquid waste which will then require processing.

Analysis:
The operational wastes from the 2004 UKRWI were used to back-fit the material contents of the trenches due to the lack of detailed materials inventory data in the historical disposals records for plastics and rubber. Although there are no specific data for the quantity of gloves consigned to the trenches, there are volume data for more general categories of waste, such as halogenated plastics (46,980 m^3), halogenated rubber (9,550 m^3) and non-halogenated rubber (4,410m^3) [1].

The building fingerprints for laboratory wastes were developed with consideration for the particular laboratory processes and practices. Therefore, there is no reason to believe that the activity arising from the disposal of contaminated gloves would not have been considered as part of the fingerprint development.

Reference:

[1] C.P. Lennon, A. Jones, L. Eden and M. Ball. LLWR Lifetime Plan: Heterogeneity of the Inventory of Past and Potential Future Disposals at the LLWR. Nexia Solutions Report (07) 9126 Issue 03, 2008.

Conclusions
The current and future inventory does account for both plastics and rubber and there is no reason to assume that a waste stream as large as gloves would not have been accounted for in the building fingerprints. As such, disposals of this type would likely have been included in the current inventory.

Any Related Issues:
None.

<u>Issue Number</u>: 16

<u>Description of Issue:</u>
Disposal of unirradiated natural uranium that could not go through the reprocessing plant, following an attempt to dissolve it in nitric acid.

<u>Potential Significance to the Inventory</u>:
The uranium isotopes U-234 and U-238 are expected to have a significant effect upon the ESC on the basis of analyses undertaken for the Requirement 2 submission to the Environment Agency in 2008 [1, 2, 3]. Thus, if there were multiple unrecorded disposals to the trenches which contained uranium this might affect the inventory significantly.

<u>Analysis</u>:
The date of the disposal that the interviewee was referring to is not clear, but it is believed they were referring to a one-off incident as they described a failed attempt to dissolve the uranium in nitric acid, before it was wrapped in polythene and sent to LLWR.

It is unlikely that this material can be specifically identified in the inventory as it is will probably have been included as part of more general “lab-waste”. Scoping calculations have therefore been performed to estimate the potential effect of such a disposal on the total uranium inventory of the trenches (12.88 TBq [4]).

Taking the specific activity of natural uranium as 25.4 Bq mg^{-1} [5] some 2.5 tonnes of natural uranium metal would be required to effect an increase to the inventory of only 1%. It is therefore not credible that even multiple disposals of depleted uranium such as described here could have any significant effect on the U inventory of the trenches.

References:

[1] A.J. Baker, Managing existing liabilities and future disposals at LLWR, LLWR Repository Ltd Report 10001 LLWR LTP Volume 1, Issue 01, 30 April 2008.

[2] T.J. Sumerling, LLWR performance update for the LLWR, LLWR Repository Ltd Report 10005 LLWR LTP Volume 5, Issue 01, 30 April 2008.

[3] N. Galais and L. Fowler, LLWR Lifetime Project: Assessment of potential impacts from human intrusion and coastal erosion at the LLWR, Nexia Solutions Report 9278 Issue 3, August 2008.

[4] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

[5] http://www.iaea.org/newscenter/features/du/du_qaa.shtml

<u>Conclusions</u>:
Even if this specific disposal was unrecorded (and even if similar disposals had occurred at various times), the scoping calculations have demonstrated that the quantity of uranium required to affect the inventory is far in excess of any realistic unrecorded laboratory disposals that could have occurred.

Any Related Issues:
None.

Issue Number: 17

Description of Issue:
Disposal of alpha and beta contaminated source trays in the trenches.

Potential Significance to the Inventory:
Under the current WAC/CfA, source trays are only accepted for disposal if they have been decontaminated. This has not always been a requirement of the CfA so for many years the source trays would have been disposed of without decontamination or washing. This change of practice indicates that their presence in the trenches could have an impact on the inventory of certain radionuclides if not already accounted for.

Analysis:
The interviewees noted that individually the source trays would be within activity limits, but collectively a large number could push the activity levels close to or above LLWR disposal limits. The contaminated source trays would have been disposed of as part of laboratory procedures and accounted for under the building's fingerprint. On this basis, the source trays would be included in the 'routine consignment' fraction of the trenches inventory. The interviewees seemed satisfied that the source trays were accounted for, but concerned that any back calculations to determine the current inventory would apply more recent fingerprints associated with the decontaminated trays, thus leading to an underestimation of the activity levels associated with the earlier source trays.

Evaluation of the significance of these disposals can only be made in the light of a likely radionuclide inventory per tray. Attempts to find this information or records pertaining to the frequency and quantity of disposals have been unsuccessful. However, the total inventory of uranium and plutonium has been determined previously; 12.88 TBq and 17.25 TBq respectively [1]. The levels of activity required to account for just 1% of these total inventories would be significant, and it is unlikely that the contaminated source trays would have activity levels of that magnitude.

It has not been possible to locate any laboratory-specific procedures for the management of used source trays, either before or after the imposition of the requirement for washing the trays before disposal. However, general procedures for the management of laboratory waste (HSR A9 and A10, [2]) stipulate the activity levels acceptable for disposal to LLWR.

References:

[1] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008..

[2] Safety in Research and Development Department – Regulations

Conclusions:
Attempts to trace any specific procedures or useful documentation for review have been unsuccessful. This waste was most likely considered a 'routine consignment' and would have been accounted for within the building waste fingerprint and therefore included via back-fitting calculations within the current inventory.

If the back calculations are based on recent waste fingerprints and consequently have not fully taken into consideration the changes in practices regarding the disposal of contaminated source trays this could lead to an underestimation of activity levels. However, when the total activity of the key radioelements associated with the source trays

is considered, any underestimation in activity levels is not expected to have a significant impact on the inventory outside the bounds of the current inventory uncertainties.
Any Related Issues: None.

serco

Issue Number: 18

Description of Issue:
Changing of floc in the Liquid Effluent Treatment Plant (LETP) was irregular and may have allowed radionuclides to be discharged to the environment,

Potential Significance to the Inventory:
The floc (ferrous hydroxide) was used in the effluent treatment plant may not have been regularly changed so it would not be as efficient at removing radioactive contaminants from liquid waste streams and as a result these contaminants could go out to sea. This would not have any bearing on the inventory associated with the LLWR unless the floc was disposed of in the trenches.

Analysis:
The floc within an effluent treatment plant, such as LETP, is used to treat any aqueous liquors containing certain radionuclides by separating any finely dispersed solid matter from the liquor prior to discharge to the environment. Due to the contamination levels of the incoming liquor, the floc is listed in the UKRWI as an ILW waste stream, 2D19.

Consequently, any reduction in the floc's efficiency should not have affected the LLWR inventory for two reasons;

1) The inefficiency of the floc might have marginally increased discharges to the environment, but this would not have any affect on the LLWR inventory.
2) Due to the high activity levels, the floc is classed as ILW and has never been sent to LLWR. Instead it has been stored, before treatment and eventual disposal in the geological disposal facility.

Conclusions:
This issue has no effect on the inventory of the LLWR.

Any Related Issues:
None.

Issue Number: 19

Description of Issue:
The occurrence of trench fires could be indicative of the disposal of flammable liquids.

Potential Significance to the Inventory:
The concern of one interviewee was that the occurrence of trench fires could indicate the disposal of flammable liquids into the trenches, in breach of the CfA. This could be of significance to the inventory if such disposals were unrecorded.

A trench fire would not have any significant impact on the inventory, since most of the combustible material is paper and cardboard, which is not known to carry any significant levels of contamination. Additionally, any trench fires were promptly dealt with either by the fire brigade and/or LLWR operatives.

Analysis:
A document written in 1976 [1] states that prior to this date there were three trench fires, which occurred in October 1961, December 1964 and November 1967 and each lasted two to seven days. Reference [1] notes that the data from monitoring downwind of the fires showed that there was no risk to the general public from airborne radioactivity. Since the fire in 1967 and the completion of reference 1 in 1976 the following measures were introduced:

1) Earth breaks/fire walls were positioned approximately every 45 m so that any fire would be prevented from spreading along the entire length of the trench.
2) The use of polythene bags for paper waste was introduced to replace paper bags, thus reducing the amount of dry paper in the trenches that could feed a fire.
3) An infra-red fire detection system was installed, which monitored the tipping face and gave immediate warning to the fire station at the Windscale Works.

A fire did occur after this in Trench 6 on 19th March 1982 (which triggered the Infra-red system), and LLWR management promptly instigated a full investigation into the circumstances and a series of recommendations was made [2]. It was determined that the most likely cause of this fire was due to the impact of a drum from an external consignor upon landing. The consigned drums were found to contain thorium residues (iand not flammable liquids).

Trench fires were mentioned by a few interviewees and whilst one expressed a concern that they could imply the disposal of flammable liquids, other interviewees noted a number of methods by which a fire could start, including from broken sodium lamps and sparks from tipped steel setting alight to nearby paper. There is evidence that some fires were significant, as the trench was occasionally dug out to inhibit fire progression.

However, the occurrence of fires in the trenches appears to have been infrequent and during the course of investigation into the documented cases, the fires have been attributed to reasons other than the disposal of flammable liquids, for which no evidence has been identified.

References

[1] E.J. Varney, Nuclear Installations Inspectorate, Nuclear Safety Advisory Committee (Radioactive Waste Study group), NSAC RW(76) P5, Sept 1976.

[2] BNFL Ltd, Enquiry into the Fire at Drigg Disposal Site on 19th March 1982, Report of the

local enquiry, April 1982.
<u>Conclusions</u>: Due to the variety of wastes consigned to the trenches, it is very difficult to determine the causes of any trench fires with any certainty. However, in each of the documented cases identified, the cause of the fire has not been attributed to the disposal of flammable liquids, thus there is no reason to believe this requires further analysis. Furthermore, the release of radionuclides by a trench fire is unlikely to have any significant impact on the inventory.
Any Related Issues: None.

<u>Issue Number</u>: 20
<u>Description of Issue:</u> The practice of leaving the trenches uncovered overnight meant that waste was being blown about the local area.
<u>Potential Significance to the Inventory</u>: This issue is not going to have any impact on the inventory as this is not related to any unrecorded disposals into the trenches. It is likely that any clean up of waste picked up by the wind would be returned to the trenches, but since it has already been accounted for on original disposal there would be no impact on the inventory.
<u>Analysis</u>: The Drigg Parish council raised their concerns regarding the loss of LLW items, such as paper towels, and their dispersion across the local area by the wind during the early period of trench operation. This issue would have little effect on the inventory as the quantities of material mobilised by the wind (e.g. pieces of paper) would be trivial in inventory terms. It is more an illustration of concern about the site management procedures. As a result of this concern, the LLWR site management put new procedures in place to prevent further incidences and loss of LLW from the surfaces of the trenches. The trenches were covered over after each day's operations, by 1m of soil. A number of the LLWR operatives interviewed on the RECALL programme discussed this as part of their day-to-day operations.
<u>Conclusions</u>: This will not have an impact on the inventory.
Any Related Issues: None.

Issue Number: 21
Description of Issue: Removal of tools from LLWR trenches after they had been sent for disposal.
Potential Significance to the Inventory: If any of the removed items were contaminated then there would be a theoretical reduction in inventory, but no significant impact is credible. The issue here is more about the efficiency of site management procedures than inventory.
Analysis: Many different tools were consigned to the trenches after they had become contaminated or ended their useful life. This issue was raised during the RECALL interviews as anecdotal evidence by one interviewee. It is not known whether there are any recorded instances of attempted removal of tools, but the police would routinely perform searches of staff leaving the site. No evidence has been found to support the comment made by the interviewee but even in the event that this was a regular occurrence there is no credible level of contamination on tools consigned to LLWR that could materially affect the inventory.
Conclusions: .There is no evidence, other than anecdotal, that any contaminated tools were ever removed from the site. However, there is no credible level of contamination on tools consigned to LLWR that could materially affect the inventory.
Any Related Issues: None.

Issue Number: 22

Description of Issue:
Erroneous disposal of Trimphones (type of phone popular in the 1970's which contained H-3 in the dials to provide luminescence) from Harwell.

Potential Significance to the Inventory:
If the disposal of Trimphones is unrecorded or incorrectly recorded then the current tritium inventory could be underestimated.

Analysis:
Terminology: The Harwell Trimphones are often referred to as 'Betalights', referring to the arrangement used to create the luminescent dials.

The disposal of Trimphones has been referred to by a few interviewees with the disposals attributed to either the MoD or Harwell. The disposals were in fact from Harwell but the MoD did consign luminous dials to the trenches (see Issue 37). One interviewee refers to the Trimphone disposal being in excess of the disposal limits at the time as the activity had been wrongly recorded on the consignment paperwork, with activities being recorded as per drum rather than per dial.

The major source of H-3 in the trenches is from the disposals of Harwell Trimphone Betalight dials made between December 1983 and April 1984 to Trench 6 [1-3]. The Betalights each contained about 7.4 GBq (200 mCi) of tritium and a total of 60,000 units were disposed. This corresponds to a total of 444 TBq (12,000 Ci) over the period, compared with a normal disposal rate of (4-8 TBq) 100-200 Ci per annum [4]. This disposal is known to have breached conditions for acceptance at the site and was later thought to have caused the release of tritium into the Railway Drain and Drigg stream, although the relatively high levels were partly attributed to the low rainfall at the time [4, 5].

An environmental assessment was carried out [6], from which it was reportedly concluded that given the relatively short half-life of tritium and the difficulty in recovering the disposals that the waste would be best left in the trenches [7]. Attempts to trace regulator correspondence have been unsuccessful.

References:

[1] C.P. Lennon, A. Jones, L. Eden and M. Ball. LLWR Lifetime Plan: Heterogeneity of the Inventory of Past and Potential Future Disposals at the LLWR. Nexia Solutions Report (07) 9126 Issue 03, 2008.

[2] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

[3] C.P. Lennon. LLWR Lifetime Project: Phase 1 Mapping and Quantification of Key Radionuclides in the Disposal Trenches at the LLWR. Nexia Solutions 8166. QRS-1356A-Ni1. Issue 3. 2007.

[4] A. Bolsover. Environmental Assessment of the Disposal of Tritium in "Betalight" dials at Drigg. August 1984. Iron Mountain archived document 00008987.

[5] A. Bolsover. Tritium in the Drigg Stream: August – November 1984. BNFL.

[6] S. R. Jones. Environmental Aspects of the Disposal of Tritium Containing "Betalight" Dials at Drigg. Incident Report 47/84. Iron Mountain archived document 00008990.

[7] P. Grimwood. Personal communications with Richard Cummings, November 2009.
<u>Conclusions</u>: The disposal of Trimphones has been recorded in the inventory and the error has been fully investigated. Attempts to trace the record of the investigation and the correspondence with the regulator for review have been unsuccessful.
Any Related Issues: Disposal of watches and dials by the MoD Issue 37.

Issue Number: 23

Description of Issue:
Storage of PCM and other higher activity wastes on the LLWR site. Includes painter's handbags full of glass vials, drums of waste and gloveboxes.

Potential Significance to the Inventory:
The waste being referred to was stored in the magazines rather than disposed in the LLWR trenches and so will not affect the disposed inventory.

Analysis:
On the western side of the consented area on the LLWR site there were ten ex-Royal Ordnance Factory storage magazines [1]. Between 1959 and 1967, some PCM ILW, contained principally within 200 l drums, was placed in these magazines for storage. The construction of a purpose-built PCM store at the southern end of the site allowed five of the magazines, which contained waste, to be emptied from 1976 onwards in the first phase of the retrieval operation and subsequently for the magazines to be demolished.

Further PCM, contained within ~11,000 drums and ~550 containers, was retrieved from the five remaining magazines, catalogued and transported to the Sellafield site, as part of a second operation, which commenced in 1997and was finally completed in 2007 [2].

References:

[1] BNFL, Drigg Post-Closure Safety Case, 2002, September 2002.

[2] http://www.llwrsite.com/news/2007-08-01/pcm-retrieval-complete

Conclusions:
This issue relates to the storage of PCM in the magazine stores and as such it does not affect the inventory of the LLWR. Relocation of the PCM has been documented and the erroneous movement of specific PCM into the trenches is investigated in Issue 1.

Any Related Issues:
Related to Issues 1, 5 and 45.

<u>Issue Number</u>: 24

<u>Description of Issue:</u>
Increasing discharge authorisation limits for Sellafield.

<u>Potential Significance to the Inventory</u>:
This is an issue relating to liquid discharges from the Sellafield site and does not involve disposals sent to LLWR. As such it has no impact on the inventory.

<u>Analysis</u>:
Liquid wastes containing low levels of radioactivity have been discharged to the Irish Sea from Sellafield since operations began in the early 1950s. The rate of discharge began to accelerate in the mid- to late 1960s, reaching a peak in the 1970s and has generally been declining significantly since then [1]. Discharges during this period of maximum release were, however, within the authorised limits [2].

This issue was first raised in 1974 out of concern that the fishing industry in the Irish Sea might be affected by increased liquid discharges from the Sellafield site. Throughout the history of the Sellafield site, the operators have conducted monitoring of the main effluent streams as well as monitoring of environmental materials and foodstuffs to establish the impact of discharges on members of the public. The history of Sellafield discharges is reviewed in Gray et al. [1] and more recent data is provided in reference [3]. Sellafield liquid discharges are currently recorded on an annual basis, see [4] and earlier reports.

References:

[1] J. Gray, S.R. Jones and A.D. Smith. Discharges to the Environment from the Sellafield Site, 1951-1992. J. Radiol. Prot. 15 99-131 (1995).

[2] A.D.W. Corbet, A.H. Fishwick, T.M. Conboy and S.R. Jones. The Control and Reduction of Liquid Radioactive Discharges from the Sellafield Reprocessing Site. BNG Report 212983.

[3] D. Jackson, B. Lambers and J. Gray. Radiation Doses to Members of the Public near to Sellafield, Cumbria, from Liquid Discharges 1952-1998. J. Radiol. Prot. 20, p 139-167 (2000).

[4] Sellafield Environmental Report. Monitoring Our Environment: Discharges and Monitoring in the United Kingdom. Annual Report 2007.

<u>Conclusions</u>:
This issue has no impact on the inventory of wastes disposed to LLWR.

Any Related Issues:
None.

Issue Number: 25
Description of Issue: Radiation measurements taken at the magazines during the course of retrievals may have been higher than those quoted to the Drigg Parish Council.
Potential Significance to the Inventory: This is an issue relating to radiation levels during the retrieval of PCM from the magazines on the LLWR site and does not relate to materials disposed of to the trenches. As such this issue has no impact on the inventory.
Analysis: This issue relates to the radiation levels reported during retrieval of PCM from the magazines, following a site visit by the Drigg Parish Council. On observing a sign next to a radiation counter instructing of a limit above which a charge-hand was to be called, the interviewee felt that the activities being monitored could not be at the low levels that had been quoted to the Drigg Parish Council. However, there is no reason to believe that the site visitors would have been misled about the levels of radiation arising from the PCM retrieval work and, as with any monitoring procedure, there would have been an upper limit above which assistance would be sought. This does not imply that the upper limit was ever reached or that this upper limit was associated with serious consequences, but that appropriate safety procedures were in place. This issue has no effect on the inventory as it does not relate to LLWR disposals, but retrievals from the magazines, which have now been completed.
Conclusions: This issue has no significance for the inventory of wastes disposed in the LLWR trenches.
Any Related Issues: None.

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Issue Number: 26

Description of Issue:
Approx. 4,500 drums were removed from temporary storage in Trench 7 (prior to disposal in Vault 8) once WAMAC opened. Having being stored for a number of years, some drums had corroded and leaked what looked to the interviewee like uranium cake.

Potential Significance to the Inventory:
This may have a bearing on the inventory if the drums were included in the inventory for Trench 7 and again when returning from WAMAC. However, if accounted for correctly, then there would be no net effect on the inventory of LLWR as a whole.
A second consideration is whether the loose material at the bottom of Trench 7 has been accounted for and, if not, whether this would have an impact on inventory.

Analysis:
Any drums that were temporarily stored in Trench 7 were not included in the disposal records until they had been processed at WAMAC and disposed in Vault 8. Electronic inventory records for Vault 8 show that over 60,000 drums of waste from a number of consignors were classified as 'Drigg backlog''WAMAC (Drigg backlog cont'rs)' [1]. It is not clear whether the waste stored in Trench 7 has been included in this total, but with the advent of more complete disposal records and stricter controls it would be unlikely that they would have remained unaccounted for in the current inventory.

Without being able to trace the specific disposal records for these drums, it is not possible to draw any conclusions as to the exact nature of the wastes that could have leaked from the corroding drums. However, as shown in the scoping calculations performed during analysis of Issue 16, some 2.5 tonnes of natural uranium metal would be required to increase the inventory by 1%. It is therefore not credible that any residues left behind in Trench 7 could have any significant effect on the U inventory of the trenches.

Reference:

[1] Access database: 88 - 07 material inventory.mdb, National Nuclear Laboratory, dated 13 December 2007.

Conclusions:
Even if the corroded drums had left behind a residue of uranium cake, scoping calculations have demonstrated that the quantity of uranium required to affect the inventory is far in excess of any realistic unrecorded laboratory disposals that could have occurred.

Any Related Issues:
Issue 39.

Issue Number: 27

Description of Issue:
All building skips were locked with padlocks, but there were problems associated with missing padlocks and the use of a single key to open all padlocks. This could have led to unrecorded disposals in the skips.

Potential Significance to the Inventory:
This issue may affect the inventory in that items or sacks of waste could be disposed of in the skips that are not accounted for by the respective building's fingerprint and therefore not accounted for in the inventory.

Analysis:
From 1959 to 1973, the building skips were not locked and it was acknowledged that waste could be tipped without the knowledge of the building's consignors. Locking the skips would prevent any such practices. However, if there were ways in which the locking of the skips could be circumvented, then any activities such as the unknown tipping of material into another building's skip could continue.

A building monitor's instruction issued in 1992 outlines the duties and responsibilities of a building's Health Physics (HP) Monitor [1]. The instruction specifies that the waste skips should be kept locked at all times, except when loading waste. Skip keys had to be signed out of the Health Physics Supervisors' Office and returned as soon as the skip had been relocked or sent for dispatch. During dispatch to LLWR, the skips would be locked by the transport drivers' own locks, so that the key was never removed from the building and the skip was never left unlocked.

There remains a question, however, over whether the introduction of these lockable skips was an effective measure. For example, site clearance operatives noted that, on a fairly regular basis, padlocks would go missing, and there is a belief that the same key could open all the padlocks (held by the skip transport driver) or that personnel other than the HP monitors were able to access the keys. Clearly, any of these actions would contravene the building and site procedures. The procedure quoted above was issued in 1980 and no information has been found regarding earlier or later site procedures. However, it should be noted that there is no evidence that this sort of practice happened to a significant extent or, indeed, at all.

It is, therefore, difficult to ascertain whether the skips would have been left unlocked, for example, if a padlock had been lost, or other personnel had access to the padlock keys. However, it would be highly unlikely that disposing of higher activity items in another building's skip would occur with any regularity, since HP continued monitoring the waste/skips to ensure transport regulations were met and then skips were monitored again at the LLWR site itself. If HP detected any waste above limits, they would instigate a full investigation as to the origin of the waste.

References

[1] British Nuclear Fuels plc, Reactor Division, Calder Hall, Building Monitors Instruction, BMI A5, Issue 2, April 1992.

Conclusions Procedures dating back to 1980 stipulate that the skips should be locked at all times, except when waste was being added. If followed correctly, there would be no opportunity for any unrecorded disposals. It is likely, however, that site procedures changed over time, especially since lockable skips were not introduced on site until 1973. Consequently, there is a possibility that unrecorded disposals occurred, especially pre-1973. However, it is unlikely that this would have occurred with any regularity due to the frequency of monitoring by Health Physics prior to disposal. If the odd waste sack was unaccounted for and if its activity was low enough that it remained undetected by Health Physics, then it would certainly not have any impact on the inventory of any key radionuclides.
Related Issues Issue 3, 5 and 13.

ISSUE 28 relates to the identification of earlier studies either noted by the interviewees or handed to EBM Strategic Consulting during the interviews. Where appropriate, the documents are described in the analysis sections of the relevant issues.

Issue Number: 29

Description of Issue:
Disposal of furnace liners (ILW) in the Sellafield LLW (B291) trenches.

Potential Significance to the Inventory:
This would not have any impact on the inventory as this relates to trenches on the Sellafield site.

Analysis:
This was raised during the RECALL programme as an illustrative example of how disposal of materials above the Sellafield B291 trench limits could be sanctioned by the site management on the basis of a proper assessment of any consequences. No supporting information could be identified but the suggestion is that this process could also have applied to disposal of materials to LLWR, i.e. if any items that could breach the CfA limits were to be tipped then there would be an investigation instigated by the site management team prior to the disposal and a paper trail outlining the decision.

It has, however, been acknowledged that disposals exceeding the operational control limit have occasionally occurred. In such cases, special justification for disposal was required to demonstrate that whilst the activity per unit area may be exceeded the overriding disposal authorisation limit was not breached [1]; see Issue 38 for further discussion. Accordingly, the disposal would be included as part of the inventory.

Reference:

[1] A. Bolsover. Alpha Activity in Drigg Waste. DLTF P84 (23) October 1984.

Conclusions:
In this case, the disposal of furnace liners into the B291 LLW trenches was known to exceed the activity disposal limits prior to disposal, and the impact fully assessed and deemed acceptable. It can be concluded that if considered disposals of this nature were made at LLWR they would have been documented and accounted for in the inventory.

Related Issues
Issue 38.

Issue Number: 30

Description of Issue:
Was any higher activity waste generated from incidents such as the Pile 1 fire disposed of in the trenches?

Potential Significance to the Inventory:
If materials from incidents that generated higher activity wastes were disposed in the trenches and not accounted for then this could have an impact on the inventory of some radionuclides.

Analysis of information from readily available data:
At the time of the Pile 1 fire the LLWR trenches were not open and all LLW was sent to the Sellafield B291 Windscale disposal trenches [1].

The B291 trenches were a series of trenches that were filled during the period 1955-1959. There is no formal record of their contents, but borehole data and interviews with former trench operators have elucidated details of typical waste streams. In reference [1], a list of items thought to be contained within the trenches is noted and includes materials from Pile 1, such as Pile filters, although one of the testimonials indicates that some waste from the Piles was also sent to North Group Pits. It was also noted in reference [1] that higher activity wastes would be sent to the B41 ILW silo, decontaminated where possible or incinerated.

Reference:

[1] J.S. Grundy, Information currently available on the area now occupied by the Windscale Disposal Trenches B291, BNFL Reprocessing Division, SSP/86/77, December 1986.

Conclusions:
All LLW was consigned to the B291 Windscale trenches during the period 1955 to 1959, which includes the time of the Pile 1 fire. Consequently it can be concluded that it is unlikely that the wastes from the Pile 1 fire were consigned to the LLWR trenches.

Any Related Issues:
None.

Issue Number: 31

Description of Issue:
Greenpeace activists broke into the LLWR site and took pictures of Trench 7 and in particular a glovebox from the laboratories (rumoured to contain PCM).

Potential Significance to the Inventory:
This would have little bearing on the inventory unless the glovebox was found to be ILW.

Analysis:
After this incident, the consignor note (D4) was found and sent to Her Majesty's Inspectorate of Pollution (HMIP) Inspector to demonstrate that the waste in question was within LLWR disposal limits and correctly consigned to the trenches. The HMIP inspector was satisfied that the disposal was within LLWR limits and consequently there was no need for any further investigation [1].

Reference:

[1] Personal communication from R Cummings quoting Paul Grimwood (Ex. Technical Manager of LLWR).

Conclusions:
This shows that the site management team acted swiftly to allay fears that higher activity waste was being disposed of in the LLWR trenches. The HMIP inspector was satisfied that there was no cause for concern. There is no impact on the inventory.

Any Related Issues:
None.

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Issue Number: 32

Description of Issue:
A quantity of C-14 was disposed in the trenches in error.

Potential Significance to the Inventory:
An external consignor had not realised that their waste stream had the potential to contain C-14 and consequently had not performed any C-14 characterisation. It was not until a random check was made, instigated by the Environment Agency (EA), that quantities of C-14 were found. Consequently this error in the fingerprint could potentially lead to a significant underestimate of the C-14 in the trenches.

Analysis:
In 1998, Devonport Management Ltd (DML) was instructed by the EA to review their wastestream characterisation/fingerprint. The review showed that their original assessment of C-14 levels was underestimated. Back calculation showed that disposals by DML over the period 1990 to 1998 had caused BNFL (the site operators at the time) to breach the annual authorised limit for LLWR disposal of C-14 (50 GBq) on at least four occasions [1,2]. Both DML and a second consignor of a similar waste stream were embargoed until a full assessment of any potential implications on the site capacity, which encompassed a local inquiry, was completed [2]. Both the regulators (EA and NII) and Ministers of State were informed and updated of progress [1]. The full investigation into the circumstances surrounding the breach and the resultant recommendations that were made are outlined in reference [2]. This indicates that the C-14 contribution from these wastes has been recognised and included in the inventory.

References:

[1] Initial Event Report No. SE 5287, January 1999.

[2] Investigator and Secretary of Inquiry, Local Inquiry into Breach of Drigg Authorisation 21st January 1999, IER SE 5287 RIR 99/2 Inquiry No99/5, May 1999.

[3] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

Conclusions:
This error was fully investigated by the site management team and the impact on the inventory has been fully recognised.

Any Related Issues:
None.

Issue Number: 33

Description of Issue:
The potential disposal of waste from the Chernobyl accident in 1986 into the trenches.

Potential Significance to the Inventory:
This issue was discussed during a number of the interviews, often prompted by the interviewer suggesting that it was not a topic that the interviewees would have raised of their own accord. Consequently, this may have little relevance to the operations on the LLWR site and inventory.

Analysis of information from readily available data:
There are two key aspects that must be considered in resolving this issue; the first is related to the trans-boundary shipment requirements for nuclear waste and the second is the documented deposition of contamination during rainfall as a raincloud moved from the former Soviet Union across parts of the world.

In the case of trans-boundary transport, the Government does not allow the import of higher activity nuclear waste with the exception of used nuclear fuel, which has been imported under contract (signed in 1976) from the following countries for reprocessing at Sellafield and (historically) Dounreay; Japan, Germany, Switzerland, Netherlands, Italy and Sweden. As such, waste from the Chernobyl incident would not have been permitted for disposal in the UK. If the UK Government were to have permitted such disposals, then it would have required a wealth of documentation to pass through borders/abide by transport regulations/disposal records for the trenches etc.

In terms of contamination spread, the force of the explosion and the following fire at Chernobyl sent radioactive material high up into the atmosphere and resulted in environmental contamination in the surrounding area and also further afield by the movement of a plume of avtivity. A Greenpeace document lists the countries affected by the deposition of contamination with a radionuclide fingerprint consistent with that from the explosion at Chernobyl. The contamination plume moved across Ukraine and Russia, central Europe and the Mediterranean, Asia and North America [1].

Contamination was deposited by rain on the ground as the plume passed over Cumbria. The Sellafield site alarms were activated by personnel caught in the rain when entering a building and from environmental monitoring points across the site. In response, levels of environmental monitoring were increased, not only across Cumbria and the Sellafield/Windscale and LLWR sites, but across the rest of the UK to try and assess the radionuclide fingerprint and the source of the contamination [2]. Special Monitoring programmes were implemented at many sites including all BNFL sites [3, 4] and data collated in reference [2].

Monitoring of radioactivity on the western coast of North America detected concentrations relative to Cs-137 of Cs-134, I-131 and Ba-140 that were in agreement with the reported Soviet discharge concentrations and indicative of new fission products [5].

As a result of the deposition of the Chernobyl contamination in the rainfall it is likely that there may have been increased quantities of soft waste such as paper towels and clothes that were used in any clear up or contaminated during the rain that required disposal at LLWR. As with all LLW generated at Sellafield, it would have been subject to all the usual monitoring and disposal procedures and any waste found above the Drigg limits would not be tipped into the trenches [3]. Consequently, it is unlikely that the fall out of this accident would have any impact on the current inventory in the trenches.

References:

[1] Greenpeace, The Chernobyl Catastrophe, Consequences on Human Health, 2006.

[2] A Compilation of the results of environmental measurements in the UK by NRPB on behalf Department of Environment, July 1986.

[3] Director of Health and Safety, Annual report on radioactive discharges and monitoring of the environment 1986, BNFL plc, 1987.

[4] D. Jackson, S.R. Jones, M.J. Faulker and N.G. Coverdale (BNFL plc), Environmental Monitoring in the vicinity of Sellafield following deposition of Radioactivity from the Chernobyl incident, *J. Soc. Radiol. Prot*, 7 (2),1987.

[5] E.A. Lepel, W.K. Hensley, J.F. Boatman, K.M. Busness, W.E. Davies, D.E. Robertson and W.G.N. Slinn, Airborne Radioactivity Measurements from the Chernobyl Plume, Journal of Radioanalytical and Nuclear Chemistry, Articles, Vol. 123, No. 1, p7-19, 1988.

Conclusions:
Monitoring data from across the UK and Northern hemisphere provided evidence that the measured isotope ratio from the rainfall contamination corresponded to that expected as a result of the Chernobyl incident.

It can be concluded that there is no significant effect on the inventory provided that any additional soft waste generated after the raincloud passed over Sellafield and Cumbria was properly recorded. There is no reason to believe that the usual procedures for the monitoring and disposal of this waste were not followed here.

Any Related Issues:
None.

Issue Number: 34

Description of Issue:
Each Sellafield building now generates a waste fingerprint on which the radionuclide inventory of its wastes is based. Over time, the fingerprint may have changed as the plant operations changed.

Potential Significance to the Inventory:
This could have an impact on the inventory in that the current fingerprints used to back-fit and calculate the estimated inventory for the trenches may not reflect the fingerprint at the time disposals were made and lead to errors in the calculation of the amount of radionuclides in the current inventory.

Analysis:
The interviewee noted that two buildings in particular had changed uses and therefore their waste fingerprints would also change - Pond 5 and B204. However, other buildings such as B30 have not.

Although buildings may have changed their operations, it does not necessarily follow that the waste fingerprint would alter substantially. Even in the event of a substantial, unrecognised, change in the fingerprint, it is not necessarily the case that the inventory of LLWR would be materially affected.

Much work has focussed on understanding the uncertainties associated with the trench disposals since much of the inventory is based on back-fitted data [1, 2], and as such this issue has not been investigated further here.

References:

[1] G.M.N. Baston, S. Magalhaes, S. Schneider and S.W. Swanton, Improvements to the Disposal Inventory of the LLWR, SERCO/TAS/003756.04/003 Issue 1, April 2011.

[2] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

Conclusions:
The effect of changing fingerprints is potentially a real one, but as its significance is the subject of other work on uncertainties in the trench inventory feeding into the 2011 ESC, no recommendations are made to amend the inventory as an outcome of this work.

Any Related Issues:
None.

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Issue Number: 35

Description of Issue:
Site clearance team (involved in site clear-up, see Issue 8) were not always fully appraised of the CfA.

Potential Significance to the Inventory:
If the site clearance team were not fully aware of the conditions in the CfA, disposals above the Drigg limit may have been made and it may raise some uncertainty in the inventory.

Analysis:
As described for Issue 8, evidence for the disposal of miscellaneous items and sacks from site clearance procedures can be found in the archived D4 records, with the highest measured dose rate recorded on the form [1]. If the site clearance team were not fully aware of the CfA, then it is possible that disposal limits were sometimes exceeded. However, due to the nature of the wastes collected by the site clearance team it is likely that they were only rarely, if ever, inappropriate for disposal at LLWR.

Furthermore, one interviewee stated that the site clearance team would send ‘any item as long as it was below a certain limit by the monitor’, which implies that monitoring was performed and confirms that normal procedures for waste handling were followed. In addition, regular monitoring was performed by Health Physics, which, as demonstrated by Issue 42, did sometimes identify waste packages within the skips with external dose rates higher than permitted. Thus, the incidences of waste in breach of the CfA being disposed and remaining undetected are likely to be rare.

It is important to note that the trenches inventory does not include specific data for every disposal, but has captured disposal records data for key consignments only [2, 3]. The inventory for any remaining pre-1993 disposals (i.e. those deemed to be less significant and referred to as ‘routine consignments’) are based on a back-fitting method applying detailed radionuclide and material inventory data from contemporary waste streams to known historical disposal volumes by consignor. Thus, should it be the case that non-compliant disposals were sometimes made by the site clearance team it is not credible that the frequency and level of activities would be sufficient to affect the current inventory to any significant degree.

References:

[1] D4 records from Iron Mountain archives. Selection of D4’s from the 1970’s were checked.

[2] BNFL, Drigg Post-Closure Safety Case, 2002, September 2002.

[3] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

Conclusions:
Evidence has been found in the archived D4’s that miscellaneous items were recorded in a manner consistent with that used for routine, laboratory disposals, potentially leading to an overestimate of the radionuclide inventory. Waste was monitored by the site clearance team in addition to regular monitoring being performed by Health Physics, which, as demonstrated by Issue 42, was sometimes effective in identifying waste packages with external dose rates higher than permitted.

It is therefore not credible that the frequency and level of activities of such disposals would be sufficient to affect the current inventory outside the bound sof the current uncertainties.
Any Related Issues: Issues 8, 10 and 44.

Issue Number: 36

Description of Issue:
Disposal of asbestos in the trenches. Asbestos was tipped in the trenches, but required additional paperwork and procedures, i.e. was placed in pink sacks for easy identification and permission had to be sought from Cumbria County Council prior to disposal. There was an area of site that stored any asbestos awaiting disposal.

Potential Significance to the Inventory:
This issue may have an impact on the chemotoxic inventory if not accounted for. The interviewees discussed the disposal of asbestos as it required different handling procedures, but nothing was said that might lead one to question the accuracy of the inventory.

Analysis:
The current inventory accounts for a total volume of 7,002 m^3 of asbestos, the majority of which can be found in Trench 4 (24.6%) and Trench 7 (29.2%). Over half of the volume is present in less than 10% of the trench disposal areas [1].

Lennon *et al.* note in reference [1] that the trench maps (concentrations in each trench bay) for the disposal of asbestos are based on an understanding that the distribution of the asbestos is based on the fingerprints of analogous waste streams in the current UKRWI, rather than the direct analysis of disposal records.

In 1981, new regulations came into operation, which meant that certain listed substances or 'Special Wastes', including asbestos, came within the terms of the Control of Pollution Act (1974). As a consequence, these listed items can only be disposed at LLWR after a licence from Cumbria County Council was obtained [2, 3]. These special wastes required additional paperwork to conform to the Control of Pollution Act, as well as additional operational procedures. In the case of asbestos, special waste skips were used for transport, and the asbestos waste itself had to be double-bagged in heavy duty PVC. This corroborates information given by the interviewees.

References:

[1] C.P. Lennon, A. Jones, L. Eden and M. Ball. LLWR Lifetime Plan: Heterogeneity of the Inventory of Past and Potential Future Disposals at the LLWR. Nexia Solutions Report (07) 9126 Issue 03, 2008.

[2] S. Atherton, Memorandum, Control of Pollution (Special Waste) regulations, 1980

[3] S. Jones, Memorandum, Control of Pollution (Special Waste) regulations, 1980

[4] British Nuclear Fuels plc, Reactor Division, Calder Hall, Building Monitors Instruction, BMI A5, Issue 2, April 1992.

Conclusions:
The volume of asbestos in the trenches has been reviewed and developed as part of the current inventory. There is no reason to question that these records fully account for the asbestos consigned to LLWR.

Any Related Issues:
None.

Issue Number: 37

Description of Issue:
Disposal of luminous dials such as watches and navigation equipment from the MoD.

Potential Significance to the Inventory:
The inventory records for H-3 or Ra-226 could be inaccurate if any such disposals were unrecorded.

Analysis:
It is not clear from the interviewee whether these luminous dials were a tritium or Ra-226 source, as both have been used in the past.

Lennon [1] used documentation from the disposal records to summarise specific disposals of tritiated wastes to the trenches between 1976 and 1982, and included consignments that were not previously included in the trench inventory calculated for the 2002 PCSC [2]. Although the dominant consignors of H-3 (other than Betalights), tended to be clock and dial manufacturers, disposals from HM Naval Base Plymouth (1980, T4-44B, 0.03TBq) and RN Base Portsmouth (1981, T4-19B, 0.19TBq) were also identified. Individual disposals appear to be confined to particular bays of Trench 4. There is no reason to doubt the activity estimates, the numbers fall within the range estimated for disposals from watch and dial manufacturers.

Although there is no specific mention in any of the documents relating to Ra-painted dials, a further disposal from DSDA North Donnington of luminised tritium and radium compounds is detailed in the inventory [2].

Evidence for the inclusion of luminous dials from the MoD has been found in the inventory and it is known that the disposals from external waste consignors were managed stringently [3].

References:

[1] C.P. Lennon. LLWR Lifetime Project: Phase 1 Mapping and Quantification of Key Radionuclides in the Disposal Trenches at the LLWR. Nexia Solutions 8166. QRS-1356A-Ni1. Issue 3. 2007.

[2] Drigg Post-Closure Safety Case: Inventory of Past and Potential Future Disposals, BNFL Report 2002.

[3] Inventory spreadsheets associated with NNL Trench Inventory Reports 9124 and 9126.

[4] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

Conclusions:
Some disposals of watch dials from the MoD have been recorded so there is no reason to suspect any other, unrecorded disposals would have been made. There is no reason to doubt the estimate of activity, and as such, there would be no impact on the inventory.

Any Related Issues:
Betalight disposals in Issue 22.

Issue Number: 38

Description of Issue:
Generation and disposal of high activity materials from buildings known to contain a lot of activity e.g. B30.

Potential Significance to the Inventory:
The inventory may be affected if the disposals were unrecorded or under-/overestimated. However, if the reference is to generic disposal of high activity materials by an appropriate route, then there will be no effect on the inventory of LLWR.

Analysis:
It is known that certain Windscale/Calder/Sellafield buildings were consignors of 'higher-activity waste', but this does not mean that disposal limits were breached or waste was unrecorded. Whilst such high activity waste is mentioned by several interviewees, only one mentioned methods used to shield items with higher than permissible surface contamination.

Early documentation shows that wastes arising from operations with alpha-active materials were segregated at source into 'high-alpha' and 'low-alpha' waste [1, 2, 3]. 'High-alpha' waste was that which may have come into direct contact with alpha-active materials, for example, inside gloveboxes, whilst 'low-alpha' waste comprises all other waste arising in restricted areas used for alpha-active work. From the start of waste disposal operations at the LLWR site, disposal of 'low-alpha' wastes in the trenches was permitted, whilst the 'high-alpha' wastes were prepared for storage, initially in the magazines on the LLWR site and later on the Sellafield site. Wastes arising from operations with beta/gamma active materials were monitored, with their consignment route determined by the maximum radiation level measured at the surface. Only those designated as 'low beta-gamma' waste was disposed of to the trenches, storage facilities were in place for wastes with higher activities. Although waste disposal and monitoring procedures have changed over the years, the waste disposal/storage principles remain broadly consistent.

Reference 4, however, acknowledges that disposals exceeding the operational control limit have occasionally occurred. At the time the reference was written, the concentration of alpha activity in waste disposed at LLWR was limited by the disposal authorisation to 20 mCi m^{-3} averaged over one days tipping. Activity concentration was not controlled directly by monitoring of this quantity but rather indirectly by an operational control limit on waste surface contamination levels to 10^{-4} μCi cm^{-2}. In such cases where the disposals have exceeded the operational limit, special justification for disposal was required to demonstrate that whilst the activity per unit area (20 mCi m^{3}) may have been exceeded, the overriding 10^{-4} μCi cm^{-2} limit was not breached [4].

The activity arising from the different types of waste has been taken into account during progressive inventory calculations [5, 6].

References:

[1] W.T.L. Neal. Disposal of Solid Radioactive Waste at Drigg. December 1960. The National Archives. Records of the United Kingdom Atomic Energy Authority and its predecessors. HLG 120/337.

[2] R. Smith. Relationship between Surface Contamination Levels and Trench Burial Authorisation Level for Low Level Alpha Active Solid Waste at Drigg. PWRWG/P1. April

1976.

[3] J. Doran. The Storage and Treatment of Plutonium Contaminated Materials and Plutonium Residues at Windscale Works. BNFL NWABM/235/28. April 1979.

[4] A. Bolsover. Alpha Activity in Drigg Waste. DLTF P84 (23) October 1984.

[5] J. Broomfield. Summary of the Activity Content of the Waste Disposal Trenches at Drigg. BNFL DLTF/P(87) 52, 1987.

[6] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

Conclusions:

It seems highly probable that interviewees were referring to disposals within the limits and as such the activity would have been accounted for under the building's fingerprint and would be therefore be included in the 'routine consignment' fraction of the trenches inventory.

In the example of waste being shielded, further analysis has been performed as part of Issue 5.

Any Related Issues:

The method of 'averaging' is investigated under Issues 3, 5 and 13.

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Issue Number: 39

Description of Issue:
Storage of 'Seal Sands' in Trench 7 prior to disposal in Vault 8. The drums of waste were stored for a number of years and consequently began to corrode spilling their contents into the trench. However, the exact composition of the Seal Sands is not clear.

Potential Significance to the Inventory:
The exact nature of the wastes and the consignor is unclear from the interview and was not possible to elucidate during further analysis. The disposal is potentially of significance to the inventory of the disposal was unrecorded.

Analysis:
It was not clear from the interview whether there was a consignor called 'Seal Sands' or a waste stream called 'Seal sands' consigned to LLWR for disposal and the interviewee was unable to elucidate further. This is clearly a colloquial term.

Seal Sands is an area on the North East coast close to the town of Hartlepool. Although the area itself is a nature reserve, it is adjacent to an area where the chemical industry has been active historically. One of these chemical factories was called Steetley Chemicals. There are records to show that Steetley Chemicals did consign thorium bearing materials to Trenches 4, 5 and 6. Around the time of Trench 7 operation/Vault 8 opening, the site had just been taken over by Redland Plc and in 1997 by Britmag. We could not find any records of disposals from Redland Plc or Britmag. Another consignor to LLWR at this time was BASF Chemicals, the first line of the plant address being 'Seal Sands'. It is not clear from the obtainable records what sort of waste they consigned. Without knowing which consignor 'Seal Sands' refers to, it is not possible to perform any meaningful scoping calculations.

According to records there are a series of consignments under the name of 'WAMAC (Drigg backlog cont'rs)' which includes over 60,000 drums of waste from a number of consignors [1]. It is not clear whether the waste stored in a fenced-off "lay-down" area of Trench 7 has been included in this total, but interviewees noted that this waste was being stored prior to completion of the WAMAC plant. After compaction, the Trench 7 waste was destined for disposal into Vault 8 and was probably a small proportion of the drums listed under the Drigg backlog in the Vault 8 inventory.

Reference:

[1] Access database: 88 - 07 material inventory.mdb, National Nuclear Laboratory, dated 13 December 2007.

Conclusions:
Since the exact nature of the wastes and the consignor remains unclear any potential impact on the inventory cannot be assessed with certainty. However, it is probable that the drums have been accounted for in disposal records, since they were processed at WAMAC prior to disposal in Vault 8.

Any Related Issues:
Issue 26.

Issue Number: 40

Description of Issue:
Leachate from the trenches was regularly monitored and could provide evidence of the introduction of a particular waste stream.

Potential Significance to the Inventory:
This issue may have significance for the inventory if contaminants not known to exist, or not quantified, within the inventory are detected in the trench leachate.

Analysis:
A wide-ranging programme of statutory and non-statutory environmental monitoring of both radiological and non-radiological contamination has been undertaken at LLWR. Leachate is sampled from the trench probes, boreholes and marine holding tanks and the water quality of streams and drains on site is monitored (see references in [1]).

The data are currently used in inventory calculations, for both the non-radioactive and radioactive inventories ([1] and [2], respectively). A recent review of all available data on the contaminant concentrations in the leachate has been performed to determine whether the data are sufficient to allow the estimation of the time-integrated release of a contaminant, for comparison against its disposed inventory [2]. A scoping calculation was performed based on the quantity of tritium released from the facility into the groundwater and drain discharge. Whilst a number of significant uncertainties were highlighted, it was demonstrated to be possible, with outcomes comparing favourably with existing estimates of the tritium inventories for Trenches 4 and 5, indicating that there is some value in the method.

Other uses of such data are the back-fitting of hazardous substances that are not recorded in the current inventory [3, 4] or their use in the assessment of human health impacts [5].

In the past there were a number of separate monitoring programmes, serving the needs of different projects (such as the Environmental Safety Case, Vault 9, trench cap performance monitoring, etc.). This led to duplication of data and a lack of overall visibility to identify gaps in the data. Significant work has been undertaken to generate an LLWR integrated Environmental Monitoring programme aimed at accounting for the needs of all of the major projects utilising monitoring data [6].

References:

[1] C. Lean, C.P. Lennon and N. Galais. Drigg Non-Radioactive Contaminant Assessment. NSTS Report 4689. 2004.

[2] E. Henderson. LLWR Lifetime Project: Leachate Data Scoping. NNL (09)10766 Issue 0.1, January 2010.

[3] M. Kelly and C.P. Jackson. Exploring the Use of GoldSim to Develop Near-field Models. Serco Report SERCO/TAS/003232/001, Issue 1, Draft, 2009.

[4] M. Kelly and D. Applegate. Updates to the Methodology for the Assessment of Non-radiological Hazards at the LLWR. Serco Report, SERCO/TAS/E002928/001, 2008.

[5] N. Barber and E. Henderson, Assessment of Human Health and Environmental Impacts Associated with the Non-radioactive Component of Disposals to the LLWR at Drigg, Nexia Solutions (08) 9442, April 2008.

[6] S.E.B. Hunter. Annual response to Environment Agency Schedule 9 Requirement 8.

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<u>Conclusions</u>: The leachate monitoring data are currently being used in inventory calculations and so this issue requires no further investigation.
Any Related Issues: None.

Issue Number: 41

Description of Issue:
Disposal of a sludge tank that had been shown to have high activity readings.

Potential Significance to the Inventory:
The inventory could be underestimated if the disposal was unrecorded or the level of contamination was under-recorded.

Analysis:
It is not clear what the origin of this disposal is and the interviewee was unable to provide any specific information, e.g. a disposal date. However, there was no implication that the disposal breached the LLWR limits or was unrecorded at the time of disposal.

One possibility is that the interviewee was referring to the disposal of a tanker-load of sludge into a trench in 1965 [1]. A 500-gallon tank was filled with low level plant sludge removed from the drying beds at the Harwell site and transported by road to the LLWR site, whereupon the contents were discharged into a 12 ft. long x 6 ft. wide x 8 ft. deep hole excavated about 25 ft. from the edge of the main trench. The liquid was initially observed to percolate fairly readily through the bottom of the trench before seepage slowed resulting in a final depth of 1 ft. of sludge. This disposal was documented as an experiment to find an alternative disposal route to dumping the drums of sludge at sea - practices have since changed and the disposal of loose sludge did not persist.

In order to assess the impact of such a disposal on the current inventory of the trenches, a series of scoping calculations were performed assuming a sludge volume of 72 cubic feet and using the radionuclide data from the Harwell 5C41 low-level sludge waste stream in the 2007 National Inventory [2]. Calculations showed that, with the exception of Cm-244 at 1.7%, no individual radioisotope would contribute in excess of 1% of their respective inventory within the trenches. This disposal would therefore have no significant impact on the current inventory of the trenches.

References:

[1] K.W. Pearce. Disposal of Low Level Sludge at Drigg. 1965. The National Archives. Records of the United Kingdom Atomic Energy Authority and its predecessors. AB 54/269.

[2] Waste stream 5C41. The 2007 UK Radioactive Waste Inventory.

Conclusions:
There is no indication that this was an unrecorded disposal or in excess of LLWR limits. In the case that the interviewee was referring to the disposal of sludge described here, scoping calculations have indicated that there would be no significant impact on the current trenches inventory. However, if this was not the disposal referred to, then without further evidence it is impossible to determine the details of the disposal and therefore to ascertain its significance.

Any Related Issues:
None.

Issue Number: 42
Description of Issue: During the routine monitoring of the skips at the skip handling facility at the edge of separation area, three bags of bird guano were found to be above LLWR limits and removed from the skip.
Potential Significance to the Inventory: During the routine monitoring of skips before dispatch to LLWR, Health Physics personnel detected some sacks where the external dose rate was higher than acceptable for dispatch to LLWR. These sacks were found to be full of bird guano. There is no evidence that this was more than a one-off incident, and on this basis there would be no effect on the inventory of LLWR.
Analysis: This incident demonstrates that the routine monitoring of the skips was, on this occasion at least, effective in identifying materials which did not meet the CfAs. An investigation was launched to determine where and why the waste was placed into a LLWR skip, although it has not been possible to obtain a copy of this report.
Conclusions: The monitoring procedures in place detected the higher activity items so that they were removed prior to disposal in the trenches. This demonstrates that routine monitoring of the skips was effective in identifying inappropriate disposals, although it also demonstrates that inappropriate materials could be introduced into the skips in error. In this case, it can be concluded that the sacks would not have any impact on the inventory.
Any Related Issues: Issues 3, 5 & 13.

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Issue Number: 43

Description of Issue:
Disposal of Springfield drums which may contain uranium residues.

Potential Significance to the Inventory:
Potentially significant to the inventory of key radionuclides if the disposals are unrecorded or inaccurately recorded as based on the analyses undertaken for the Requirement 2 submission to the Environment Agency in 2008 [1, 2, 3], U-234 and U-238 are expected to have a significant effect upon the 2011 ESC. ,

Analysis:
No dates are referred to by the interviewees who discussed these disposals. However, it is known that residues and contaminated scrap disposals to the LLWR trenches from the Springfields site in the period up to around 1985 account for around 95% of the trench uranium [4]. Uranium is distributed widely across the trenches, but the highest levels are found in Trenches 4 and 5 from 1979 to 1983 [5]. The waste from Springfields is comprised mainly of uranium hexafluoride residues, powder and scrap in drums or bales. The dominant descriptor in terms of activity contribution is 'residues in sealed drums', which accounts for 15% of the uranium activity in the Springfields trench inventory, whilst hex reactor residues account for a further 2.5%.

A significant proportion of the records of these disposals was captured for the 2002 PCSC inventory assessment [4]; the remainder being captured more recently for the trench mapping study [6] undertaken for the LLWR. In this latter study, Springfields was identified as the majority consigner of uranium to the trenches and data taken from over 4,000 disposal records were processed to map the significant uranium disposals within the trenches.

References:

[1] A.J. Baker, Managing existing liabilities and future disposals at LLWR, LLWR Repository Ltd Report 10001 LLWR LTP Volume 1, Issue 01, 30 April 2008.

[2] T.J. Sumerling, LLWR performance update for the LLWR, LLWR Repository Ltd Report 10005 LLWR LTP Volume 5, Issue 01, 30 April 2008.

[3] N. Galais and L. Fowler, LLWR Lifetime Project: Assessment of potential impacts from human intrusion and coastal erosion at the LLWR, Nexia Solutions Report 9278 Issue 3, August 2008.

[4] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.

[5] C.P. Lennon, A. Jones, L. Eden and M. Ball. LLWR Lifetime Plan: Heterogeneity of the Inventory of Past and Potential Future Disposals at the LLWR. Nexia Solutions Report (07) 9126 Issue 03, 2008.

[6] C.P. Lennon. LLWR Lifetime Project: Phase 1 Mapping and Quantification of Key Radionuclides in the Disposal Trenches at the LLWR. Nexia Solutions 8166. QRS-1356A-Ni1. Issue 3, 2007.

Conclusions:
Consignments of waste from Springfields occurred on a regular basis with disposals

seemingly well-documented; as such, there is no reason to believe that some disposals may have been unrecorded. It is thought highly probable that the Springfield drums referred to by the interviewees have been included in the inventory.
Any Related Issues: None.

Issue Number: 44
Description of Issue: The sacks of LLW were monitored outside the building of origin and it is unclear whether a background correction was applied.
Potential Significance to the Inventory: If there was not background correction, then this could lead to a significant overestimate of the activity within particular packages and the current inventory.
Analysis: Other than the information provided in the interviews, no supporting documentation relating to procedures for the monitoring of waste before disposal in the skips or information as to whether any background correction has been applied to the inventory data has been identified. It was noted that the building HP monitor would measure the dose rate arising from the sacks outside the building of origin before they were placed in the skip. However, in spite of the fact that all sacks were monitored, only the highest reading was noted on the records that would have been used to build the inventory. It has been noted that no background correction was made at the time of monitoring. In the event of significant background radiation, this could lead to an overestimate, potentially significant, of the inventory of the sack. More modern procedures involve the use of lead shielding during measurements to reduce the background dose.
Conclusions: If no correction for background radiation has been made when monitoring the waste then the inventory will be overestimated. Whilst there is no doubt that it is advantageous to have a more accurate measurement of the activity levels in the inventory, it is better to be conservative rather than base any calculations/performance assessments on underestimated data. However, any overestimation is likely to fall within the bounds of the current inventory uncertainties.
Any Related Issues: None.

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Issue Number: 45

Description of Issue:
Disposal of unwashed uranium and plutonium-contaminated glass vials from the laboratories.

Potential Significance to the Inventory:
The inventory of key radionuclides could be underestimated if this was a regular waste stream that was previously unaccounted for in the LLWR disposals.

Analysis:
The interviewee did not indicate whether the residual radioactivity within the glassware was recorded or not and, perhaps more importantly, did not know the disposal route for the glassware following removal from the laboratory.

Examination of the inventory spreadsheets [1] showed that glassware is a known component of some of the laboratory waste streams sent to LLWR for disposal. However, as previously described for Issue 38, wastes arising from operations with alpha active materials were segregated at source into 'high-alpha' and 'low-alpha' waste [2, 3, 4]. 'High alpha' waste, that which may have come into direct contact with alpha active materials, was prepared for storage, initially in the magazines on the LLWR site and later on the Sellafield site. It is likely that the glass vials were categorised as such.

The disposal of unwashed glassware is assumed to have occurred to minimise the generation of active liquid effluent. Assuming further that this was an authorised disposal practice, the radionuclide fingerprint of the vials should have been accounted for in the overall fingerprint of the building if they had a material effect on the waste stream inventory. Although individual buildings may have had different procedures, review of laboratory procedures [5] indicated that the overriding regulations for the disposal of radioactive liquid waste were outlined in HSR A12 and A13. However, attempts to trace the HSR documents for review have been unsuccessful.

The worst (although rather unlikely) case is that the materials in these vials have not been accounted for, particularly if disposals of this nature occurred at high volume and/or high frequency. However, the total known trench inventories of uranium (12.88 TBq) and plutonium Pu (17.25 TBq) [6] is sufficiently large that it does not seem credible for contaminated glass vials to represent a significant perturbation.

References:
[1] Inventory spreadsheets associated with NNL Trench Inventory Reports 9124 and 9126.

[2] W.T.L. Neal. Disposal of Solid Radioactive Waste at Drigg. December 1960. The National Archives. Records of the United Kingdom Atomic Energy Authority and its predecessors. HLG 120/337.

[3] R. Smith. Relationship between Surface Contamination Levels and Trench Burial Authorisation Level for Low Level Alpha Active Solid Waste at Drigg. PWRWG/P1. April 1976.

[4] J. Doran. The Storage and Treatment of Plutonium Contaminated Materials and Plutonium Residues at Windscale Works. BNFL NWABM/235/28. April 1979.

[5] Safety in Research and Development Department – Regulations.

[6] A.S. Wareing, Eden L, Jones A and Ball M. LLWR Lifetime Plan: The Inventory of Past and Future Disposals at the LLWR, Nexia Solutions Report (07) 9124 Issue 3, April 2008.
<u>Conclusions</u>: Procedures for the handling of such wastes were outlined in the HSR documents and laboratory procedures. It is unlikely that this type of waste was consigned to the trenches but, if so, it is thought likely that the wastes would have been accounted for within the building fingerprint. In the case that the disposals were unrecorded, then they would be unlikely to significantly affect the inventory outside the bounds of the current inventory uncertainties.
Any Related Issues: Linked to fingerprint Issue in 34 and painters' handbags in Issue 5.